İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

PROPOSAL FOR MODULAR FAÇADE DESIGN

Master Thesis by
Mine ŞENYÜRÜK, M.Sc.

Department : Architecture

Programme: Building Technology

JANUARY 2004

İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

PROPOSAL FOR MODULAR FAÇADE DESIGN

MASTER THESIS by
M ne ŞENYÜRÜK, MSc.

502011138

Date of submission : 22 December 2003

Date of defence examination: 14 January 2004

Supervisor (Chairman): Assoc. Prof. Dr. Mırat AYGÜN

Members of the Examining Committee: Assoc. Prof. Dr. Ömür BARKUL (Y.T.U)

Assist. Prof. Dr. Cem ALTUN (I.T.U)

JANUARY 2004

İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

MODÜLER CEPHE TASARIMI İÇİN ÖNERİ

YÜKSEK LİSANS TEZİ

İnş. Müh. Mine ŞENYÜRÜK

502011138

Tezin Enstitüye Verildiği Tarih : 22 Aralık 2003

Tezin Savunulduğu Tarih : 14 Ocak 2004

Tez Danışmanı : Doç. Dr. Murat AYGÜN

Diğer Jüri Üyeleri : Doç. Dr. Ömür BARKUL (Y.T.Ü)

Yard. Doç. Dr. Cem ALTUN (İ.T.Ü)

OCAK 2004

ÖNSÖZ

İnşaat mühendisleri ve mimarlar bina üretim sürecinin iki önemli ayağını oluşturuyor. Bu sürece mimarlar daha çok sanatsal, mühendisler ise sayısal yetenekleri ile katkıda bulunuyorlar. Tasarım problemlerinin çözümünde iki farklı disiplin arasında etkin bir iletişim ve bilgi alışverişinin gerekliliği kesin, ancak iletişimin yolu çoklukla bakış açısı farklılıkları, ortak bir dilden yoksunluk gibi problemlerle kesiliyor.

İnşaat mühendisliği öğrenimim sonunda hissettiğim, diğer tarafı daha iyi anlamak ihtiyacıyla başladığım bu programı tamamlarken, amacıma nispeten yaklaştığıma inanıyorum. Bu çalışmam sırasında bilgisi ve sabrı ile bana yardımcı olan danışmanım Sn. Doç. Dr. Murat AYGÜN'e buradan teşekkürü borç biliyorum.

İstanbul, Aralık 2003 Mine ŞENYÜRÜK

PREFACE

The building process largely depends upon the works of civil engineers and architects. To this process architects contribute primarily with their artistic and engineers with their quantitative abilities. Solution of the design problems necessitates effective communication and exchange of information between these two different disciplines which often encounters language and perspective problems.

As I am completing this program, that I chose by the need I felt to have a better understanding of the other party after an education as a civil engineer, I believe I have managed to come closer to my intentions. I would like to thank my supervisor Assoc. Prof. Dr. Murat AYGÜN who has consulted me with patience during my studies.

Istanbul, December 2003 Mine ŞENYÜRÜK

TABLE OF CONTENTS

ABBREVIATIONS

A. C	:	Artificial Component
J. C	:	Joint Correction
T. J. C	:	Total joint correction

TABLES

FIGURES

MODÜLER CEPHE TASARIMI İÇİN ÖNERİ

ÖZET

Bu çalışmanın amacı modüler prensiplerin bina cephe tasarım ve inşasında kullanımının getireceği faydaları göstermek ve modülerlik kavramının cephe tasarımına nasıl uygulanabileceği konusunda bir öneri getirmektir.

Çalışmanın giriş bölümünde sürekli artan yeni bina ihtiyacından ve bu ihtiyacı çabuk karşılayabilmek adına kaliteden ödün verilmesi hatasına düşülmemesi gereğinden bahsedilmektedir. Bu nitelik nicelik ikilemine çözüm olarak modüler tasarım önerilmektedir. Modüler tasarım boyutsal olarak koordine edilmiş komponentlerin, bu komponent boyutlarının katı olarak boyutlandırılmış açıklıklarda kullanılması suretiyle komponentlerin onlara ayrılan boşluklara uydurulması için gerçekleştirilen işlemlerin ortadan kaldırılması prensibine dayanır.

Çalışmanın ikinci bölümünde modüler prensiplerin kabulünün bina üretim sürecinin komponent üretimi, tasarım ve inşaat aşamalarında sağladığı faydalar ayrı ayrı incelenmektedir.

Çalışmanın üçüncü bölümünde modüler cephe tasarımı için bir öneri getirilmektedir. Bu öneri ortagonal bir referans sistemine oturan ve kat yüksekliğinin kat boyunca sabit kaldığı tüm binalarda kullanılabilmektedir. Bu öneride cepheler bir bütün olarak değil parça parça boyutlandırılmakta daha sonra bir araya getirilerek cephe boyutuna ulaşılmaktadır. Bu parçaların seçilmesindeki kriter cephe yönünün değiştiği köşeler olarak seçilmiştir.

Öneride cepheler örme ve giydirme olarak iki farklı grupta incelenmiştir. Bu iki grubun boyutlandırılmasında etkili olan ortak ve farklı pek çok özellikleri vardır. Birinci özellik plandır. Değişik plan tiplerinin boyutlandırmadaki etkileri örme ve giydirme cepheler için formüle edilmiştir.

Örme cepheler, bina iskeletinin içerisinde dolgudur, bu sebeple dizilimleri taşıyıcı elemanlar ve kapı ve pencere çerçeveleri için bırakılmış boşluklardan etkilenir. Bu etkiler içerisinde yer alması muhtemel olan dış cephe ile kesişen iç duvarlar bu çalışma kapsamında yer almamaktadır. Binalarda dolgu iç duvarlar kullandığı varsayılmaktadır. Mutlaka örgü iç duvar kullanılması istendiği takdirde bu duvarların cepheye metal bağlar yardımıyla kenetlenmesi gerekmektedir.

Şaşırtma, örme cephelerin boyutlandırılmasını etkileyen başka bir özelliktir. Tezde şaşırtma boyutunun belirlenmesi kullanılacak modülün boyutları ile ilgili bir takım sınırlamalar da getirmiştir. Örme ve giydirme cepheler boyutlandırma metodular açısından farklılık gösterseler de modüler bir cephe ancak tasarım ve komponentler beraberce gerekli sınırlamalara uydukları takdirde elde edilebilmektedir.

Giydirme cepheler hem bina ile bir bütün hem de binadan ayrıdırlar. Örme duvar gibi dolgu vazifesi görmediklerinden süreksizlikler boyutlandırmalarına etki etmez. Sürekli göz önünde olduklarından aynı zamanda bir estetik ifade aracıdırlar. Birden çok komponent kullanılması, komponentlerin kendi aralarındaki düzeninde çeşitli oynamalar yapılması gibi tasarım prensiplerinin kullanılmasının etkileri giydirme cephe boyutlandırma önerilerinde dikkate alınmıştır.

Dördüncü bölümde çalışma kapsamında geliştirilen bilgisayar programı anlatılmıştır. Bu program kullanıcının girdiği cephe boyutlarını bölüm 3'te elde edilen prensipler doğrultusunda en yakın modüler cephe boyutlarına çevirmekte kullanılmaktadır. En fazla 40 köşe noktası içeren cephelerde kullanılabilmektedir. Program cepheleri bir bütün olarak değil her yönünü ayrı ayrı incelemektedir. İlk olarak programa bilgilerin girilme formatı ile ilgili bilgi verilmiş daha sonra bu bilgilerin program tarafından nasıl işlendiği açıklanmıştır. Bu programda kullanılabilecek örme ve giydirme cephe elemanları ve süreksizliklerin boyutları ile ilgili sınırlandırmalar belirtilmiştir. Daha sonra programın en yakın modüler boyutları nasıl hesapladığı anlatılmış ve en son olarak sonuçların sunuluş şekli açıklanmıştır.

Dördüncü bölümün sonunda program tarafından çözülmüş dört adet örme ve beş adet giydirme cephe örneği verilmiştir. Örme cephe örnekleri çeşitli süreksizlik kombinasyonları ve sıfır süreksizlik versiyonlarını içermektedir. Program tarafından önerilen boyutlar, girdiler ile karşılaştırılarak süreksizlerin boyutlandırmaya etkisi gösterilmiştir. Giydirme cephe örnekleri ise değişik adette modül kullanım ve bir modüle öncelik verilmesi versiyonlarını içermektedir. Program tarafından önerilen sonuçlar, girdiler ile karşılaştırılarak farklı modül adedi ve bir modüle öncelik verilmesinin boyutlandırmaya etkisi gösterilmiştir. Bütün örnekler için önerilen boyutlar, girdiler ile karşılaştırılarak modüler boyutlara ulaşmak için gerekli değişim yüzdesi de gösterilmiştir

PROPOSAL FOR MODULAR FAÇADE DESIGN

SUMMARY

The aim of this thesis is to demonstrate the benefits of using the concept of modularity in the design and construction of building façades and make a proposition on how to apply this concept to its design phase.

The introduction part of this thesis concentrates on the increasing demand for new buildings to answer the needs of urban life and the pitfall of providing high quantities with the sacrifice of quality that is faced by building professionals. As an answer to this dilemma the thesis suggests modular practice; a system of building which employs dimensionally coordinated components in clearances dimensioned as multiples of these components thus eliminating the need for reshaping materials.

The second part of the thesis emphasizes the benefits of adopting modular practice. Modular practice consists of three phases; component manufacture, architectural design and construction. Distinct benefits at each phase are handled separately.

In the third part, a modular façade design proposition is made. The proposition is valid for façades that fit into an orthogonal reference plane in which the walls follow two directions perpendicular to each other and heights of storeys are uniform throughout the whole floor perimeter. In the proposition a façade is not considered as a whole but as the sum of many sections. Sections are defined as outer wall segments that lie between consecutive corners where façade direction changes. It is suggested that façade sections are dimensioned discretely and than brought back together to the form of a façade.

Façades are divided into two groups as masonry and curtain walls. The common and differentiating properties of these groups that must be taken into account while dimensioning are explained along with solved examples. The first description is given on the plan view property. Different effects of plan view types on dimensioning of masonry and curtain wall façade sections are formulated.

Masonry is an infill; its course is disturbed by the skeletal system as well as door and window frames. Discontinuity causes, openings such as those left for frame placement and structural necessities such as columns are properties of masonry that effect dimensioning. Internal walls intersecting with the façade are not considered as discontinuity causes. The buildings considered use partition walls, plaster or plywood panels which are stabilized by studs even if internal masonry walls are used they are considered to be bonding to the façade by the use of metal ties. Load bearing internal walls that penetrate into the façade and effect component alignment are not in the scope of this thesis.

Staggering is another property of masonry that effects dimensioning. In the thesis the formulation of the amount of stagger also dictated some limits regarding component dimensions. Although masonry and curtain walls differ in dimensioning methods, in both groups, a modular façade can only be achieved when both the components used and the design itself fulfills some requirements.

Curtain walls are formed by panels hanging from edges roofs or floor decks, they are attached to the building but also separate from it. Because curtain wall façades are on permanent display they are also a form of esthetic expression. The effects of design principles such as the use of multiple components and alignment manipulations on dimensioning are formulated instead of discontinuities and stagger in masonry.

In part four the computer program which is designed as a part of this thesis is explained. It is used in revising proposed façade dimension to modular dimensions by the use of the principles explained in part three. It can be used in calculations of façades employing up to forty corner points. The program considers façades not as whole but as separate sides. First information is given on the format of entering the proposed façade data into the program, and then how the program analyzes this data to get section properties is explained. Dimensional properties that must be embodied by masonry and curtain wall components and discontinuities suitable for use in this program embody are explained. Then how the program makes use of this data to reach the closest module quantity is shown. Finally the way the program presents the results is described.

In the end of the fourth section four masonry and five curtain wall façade examples are solved showing the use of the program in detail. Masonry façade examples are solved with a variety of possible discontinuity combinations and also without discontinuities. The results of different examples are compared showing the effect of different discontinuities on suggested dimensions. Curtain wall façade examples are solved employing different quantities of components with and without alignment manipulations. The results of different curtain wall façade examples are compared showing the effect of component quantities and manipulation on suggested dimensions. Suggested dimensions from all examples are also compared with the proposed results to show the percentage of change required to attain modularity.

1. INTRODUCTION

Everyday the world is getting more urbanized, our man-made environment, the cities, the suburbs are expanding. Population is constantly rising, traffic is increasing, schools and hospitals are getting more crowded. With housing being in the center, there is a constantly increasing pressure to provide more systems of living, complete with educational, industrial, commercial and recreational and health facilities.

When trying to answer these urgent construction needs, it is quite tempting to provide enough space with the sacrifice of quality, which alone would not solve the problem, because of the "increasing sophistication in public taste and advancing concepts of health, education and industry that call for facilities of greater quality and complexity than ever" (Darlington et al, 1962). Poor standards are not the only way of attaining affordability. On the contrary low quality construction, less attention to design and detail, obligates renewal work and design adaptations, which in the end melts away the savings made in the beginning.

According to Italian architect Duccio Turin there are some typical features of conventional buildings which shape the nature of the building industry. One of them is the relative uniqueness of the final product and the variety of the production and installation processes which necessitate a distinct organization and a high number of specialists. The construction site is a temporary factory to which materials, machines and people are transported. Fixation of this factory to a particular site forces some part of the industry to be mobile. From the need for mobility arises the problem of transportation of large and heavy materials to distant locations. There are high initial and running costs including machinery, raw materials, components, the crew etc., and there is a long production time until investment return. Attempts to improve the efficiency of the building process involves changing these features; using lighter materials or using components available from local manufacturers or effective preplanning of site mechanization and operations. (Groak, 1992)

Such rationalizations in the building industry are important because making of buildings and renewal of the built environment forms one of the largest industrial activities in every country. According to statistical data from Groak (1992) even without taking into account a large amount of unrecorded construction work, construction industry worldwide still accounts for 1.000 billion USD worth of work and it amounts to about 10% of Gross Domestic Product of countries. In an industry so vast in scale even the slightest improvement results in significant savings

A technical innovation in the building industry has been the introduction of prefabricated component production. The idea of using high quality, precision made, mass-produced components that are assembled on site, is the application of a technological miracle to the building industry which has brought luxury items like TVs and automobiles to be the basic parts of our lives. According to Leon (1971) the shortage of available skill required to produce the large number required for buildings of all types prepared the ground for this industrialization. With mechanized methods of factory production and site erection, for manufacture, assembly, and rapid construction of standardized buildings and component parts, greater productivity is achieved, site labor requirements are minimized and total construction costs are reduced.

Factory produced structural steel columns, precast concrete elements and mass produced non structural components are already widely used in the industry because of the increased productivity they induce. Being modular is yet an additional attribute to the way things are prefabricated then used in design and on site. It aims to relate components to each other and to the design in a way that when accepted by the building community, both design and site operations will be simplified, the present unnecessary and artificial factors that inflate construction costs will be avoided even more than achieved until now.

The word "module" is derived from the Latin word "modulus" which means, measure. It does not denote a specific magnitude. The concept of module is very old, in ancient buildings, are found the evidence of the use of modules as a regulator of dimensional ratios, used centuries ago by Egyptians, Greeks and Romans.

In modern architecture, modular practice stems from the initial work of Albert Farwell Bemis, an American industrialist who had a deep interest in social housing development. Bemis tried to apply his knowledge of industrial production techniques to the building industry aiming to eliminate the inefficiency, waste and high cost caused by the existing methods of assembly of unrelated materials. In 1936 he proposed a design method, where all the building components, in all three dimensions of the building would be designed according to a module of 4 inches. Bemis' ideas gained a lot of attention in the building industry; this was a radical change in perspective in respect to the interpretation made by classical culture. The module ceased to be a tool for the aesthetic control of architecture, and was instead transformed into a practical, functional tool which had an objective of changing construction work into a more factory-like activity. Laura Badii points out to the fact that this modern concept of modular coordination is strictly linked to the industrialization of the building industry. With industrialization, module became a fundamental dimensional element, a common reference, both in the design process and in the production process.

Different proposals regarding the value of the module were put forward many countries even transformed this rational thinking into standards for component production. Architects were encouraged to use modular components and apply modular design principles into their designs as means of reducing building costs.

In this thesis concentration is on the modularity of a single building element the façade. What is tried to be achieved is to arrive at a method of design for building façades based on modules. It has not been tried to arrive at certain sizes or examine the appropriateness of the current accepted modular system based on the basic module of 100 mm for façade construction. The aim is to find the dimensional requirements of a variety of elements that can be employed in the construction of a façade and formulate a method for the design of façades to be constructed using these components without the need for any alterations of these components.

2. MODULAR PRACTICE

Darlington (1962) defines modular practice as an industrialized building system in which all materials, components, products and equipment are dimensionally and functionally coordinated, fitted together simply and easily with minimum alterations resulting in improved productivity and efficiency, and elimination of waste and confusion.

In professions with artistic inclinations, along with the word industrialization a negative image comes to mind. The term conjures up with images like unattractive and poorly made, instead of innovative. This is probably caused by many common forms of prefabricated temporary structures with few storeys and limited design configuration. Modular practice however should not be confused with them as it represents a distinctly different structure and construction technique.

The term modular denotes a method of design and construction for permanent buildings which use standard materials, identical construction methods and have no strict design limitations. Modular practice takes the best aspects of traditional construction methods and advantages of prefabrication and combines them. In the end it gives a custom, long-lasting product in significantly shorter time frames than traditional site construction.

A good representation of modular practice can be the Lego toys where all pieces are multiples of a single module and fit together simply and easily. On the other hand traditional practice resembles a puzzle where there are thousands of choices for each gap and only one correct answer. All other pieces have to be checked with a keen eye to find the perfect match. Although many people with this challenging, in real life it means loss of time and money.

2.1 Benefits of Implementing Modular Practice

In his speech at the modularity conference in 1969 Hyde stated that, compared to the little concern given to putting unrelated items together in design and cost planning phases, according to statistics it accounted for 40 to 50 percent of construction time, and 75 to 80 percent of the problems with the finished building. The desire to keep the number of standard sizes of factory build components to a minimum and consistent with each other lies in this. There is no fundamental difference between the requirements of a shopping mall, hospital or a hotel. But still at present, components are being manufactured in excessively large number of types. There is a multiplicity of heights, widths, depths, of all vertical and horizontal dimensions used in design; resulting in confusion for the manufacturer, designer and contractor and also dissatisfaction for the owner.

2.2 Benefits for the Component Manufacturer

There is an extensive system of factory produced materials and components; materials such as timber, brick, and manufactured components like door and window furniture, roof trusses, structural steel work and specialties like pipe work, radiators, boilers etc. The number of stock sizes is already high and every once in a while there are also requests for special sizes.

The introduction of new materials or sizes is always a problem for the manufacturer. The design of factory produced components should correlate the requirements of demand, material and performance specifications, junction details, amounts of prefinishing, application to different buildings, site erection requirements, transportation limits. In addition to these, building components from different manufacturers must be compatible with each other to be effectively marketed and used.

The present chaotic situation of construction materials leads to other problems from the manufacturers' point of view. Producing smaller amounts of a variety of materials requires short runs, changing machines and materials every often, which leads to time and energy consumption by such ancillary work. Producing large amounts to satisfy a vast and continuous volume of demand increases productivity and reduces costs by long series of runs and bulk purchase of raw materials.

Large and automated production lines needed for production, might require intensive capitalization. Decreased utilization of expensive machinery caused by insufficient volume of constant demand may be the only disadvantage of adopting such a method. When designers recognize the availability of standardized components and tend to use more, manufacturers will secure continuity of orders.

2.3 Benefits at the Design Stage

Design is an important issue, as it considers problems at the source when they are not yet generated. Designers have an important role to play in efficient building because they can influence the design concept and measures, material selection and construction methods.

The architect must combine the many available sizes of different products in the solution of a design problem, it is necessary to find a method for relating all items for economical and efficient construction. Many common building components have already established standard dimensions and are prevailing practice among architects. These come partly from the industry, partly from regulations and are partly related to human figure. Many other common components however are not subject to such limitations. From the designers' point of view, the flexible type of standardization will simplify design work by enabling buildings to be dimensioned using standard components.

Even with this standardization there still is the freedom to use different materials, textures, colors, shapes and design principles of proportion, repetition, harmony and balance to create different feelings and senses. Modular practice does not also preclude the use of nonmodular materials. In no case should the module dictate the area to be enclosed or the materials to be employed, for this can only be determined by functional requirements.

Architects who are responsible for the design often don't see the building while it is being built and unfortunately don't have the chance to profit from lessons to be observed. They usually lack the degree of professionalism and expertise to approach the design taking into account how the building will be made on site. By using modular components and dimensioning accordingly, this need is automatically fulfilled.

2.4 Benefits at the Construction Stage

Traditional building technology relies heavily on conventional cast in-situ method where building components are made on site, shaping materials by hand tools, scaffolding or machinery to fit their required position in the structure. If the components were made of soft materials like dough they could easily be cut and changed in shape. Unfortunately this is not the case. Building materials of today are hard and durable, to resist the degradation over time. Some require specialized equipment to shape, others like door or window frames and glass blocks can not be changed in shape at all after manufacture. Common practice combined dominant, machine made components with those that can easily be cut and shaped, such as brick or wood.

There is a great variety of building processes performed by different craftsmen. The speed of operations is mainly determined by the ability of the operatives ranging from apprentice to master. Even master craftsmen put considerable effort into tiresome detail work which can be precisely and quickly made by a machine. Many craftsmen are not even used to checking their work properly. Their tests often don't go beyond banging or a superficial look. For example a factory produced element might be finished sufficiently smooth as to require no decoration when exposed, due to more controlled and accurate factory processes standards of finish will be improved. When using modular components there will be no additional shaping required site work will be simplified by rationalized assembly of building components and by the elimination of cutting, fitting and patching of components. Quantity of damaged materials will be minimized. There will be reduced purchase quantity and material costs. Reduced allowance for snagging will bring a more accurate calculation of the necessary component input problems of insufficient or surplussed materials will be minimized. The number of craftsmen required on the job will be minimized as well as the skill expected from them. Maximum economy of labor and speed will be achieved on site.

Increased productivity on site will reduce construction time enabling early occupancy and income realization from the structure. Earlier return of investment for the owner, saved labor, lower costs, shorter construction time, improved quality and appearance, safer, quieter and cleaner work environment are important advantages of modular practice which make it not only desirable but also necessary.

3. PROPOSED METHOD FOR MODULAR FAÇADE DESIGN

Previous sections have shown the need for efficient building and presented modular practice as an answer to this need. In designing a building, many elements can be planned according to modular principles but because of varying functional needs each might require different types of components and might have different dimensional limitations. This section concentrates on modular design of a specific building component, the façade.

3.1 Façade Design

There are many factors that must be taken into account in the design of façades. Factories, hotels, housing, recreational, educational and health facilities, all require different façades. Some might necessitate more emphasis on functionality and ergonomics where others give more value to esthetics. Function affects architectural style, finish, materials, design issues such as façade movements and labor complexity. Function along with climate, also regulates the fenestration. Fenestration is the connection of the inhabitants to the outside world but it is also a source of high maintenance costs. The design and placement of the opaque and transparent sections must take into account yearly and daily illuminance of the building to make the most of available daylight. Shading must be given importance for reduction in cooling costs. Climate of the location is an important factor for the layers of insulation. Good façade design is the key to good thermal and visual comfort and significant heating, cooling and lighting electricity cost savings.

There is a great variety of façade kinds used in buildings ranging from skyscrapers to rural housing, employing all sorts of materials from glass, to bricks, to blocks, to room size precast concrete wall components. They can be classified into two major groups as masonry and curtain wall façades. Curtain walls are formed by panels hanging from the edges of roofs or floor decks. Although they are attached to the building they are also separate from it. Masonry however is an infill fixed inside the skeletal framework. Although they differ in dimensioning methods, in both groups, a modular façade can only be achieved when both the components used and the design itself fulfills some requirements.

3.2 The Modular Façade Component

Components are placed next to one another, or on top of each other to fill space. Neighboring masonry components are joined along their adjoining faces by joints. Neighboring curtain wall components are separated by joints, framing, gaskets etc. The thicknesses of joints are the same all around the component. By the term modular component dimension, is meant a components length, width or height plus one joint thickness along that chosen measure's direction.

$$\textit{Modular Dimension of Component} = \textit{Component Dimension} + \textit{Joint Thickness} \quad (3.1)$$

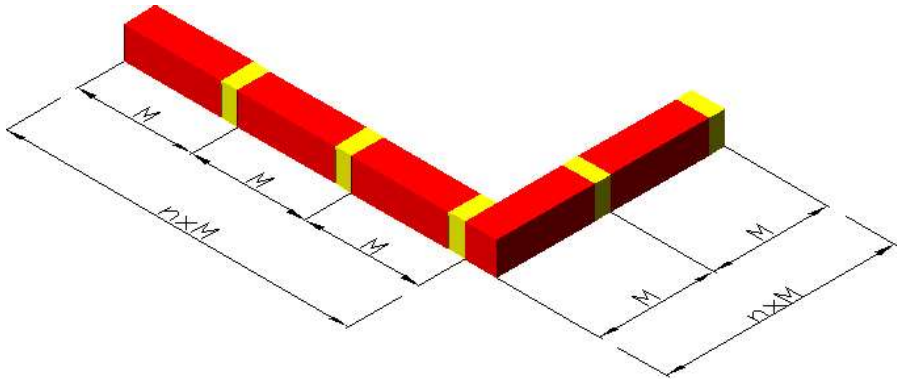


Figure 3.1: A modular masonry row

The height or length of a façade is calculated as a multiple of the modular height or length of the component respectively. If the multiplier is an integer it means the components are intact. If the multiplier is not an integer then the components are not intact then the value must be rounded to an integer value to obtain a modular façade dimension.

3.3 Façade Sections

The façade of a building can be assumed as the combination of many smaller sections. These sections lie between two consecutive corner points where the direction of the façade changes. In figure 3.1 is a façade with eight points and seven façade sections. Total dimension of a façade can be found by dividing it into such sections, dimensioning them discretely and then adding them up.

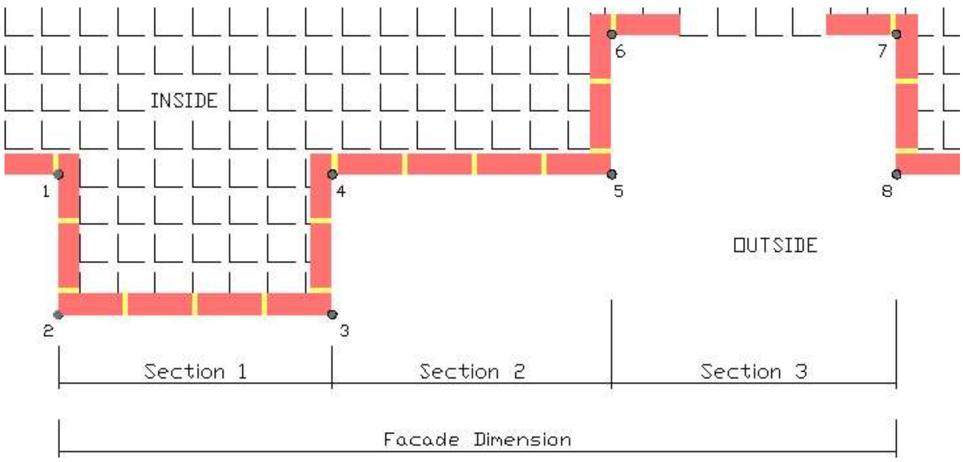


Fig 3.2: Façade sections and limiting end corners

Façade sections have properties that have specific effects on their dimensioning. Some might have different plan views, some might embody doors, windows or columns, and some might be constructed using multiple components. The first property, plan view, is an issue common to both masonry and curtain wall façades. The second property, discontinuities, is considered only for masonry types and the last one using multiple components is mainly a feature of curtain wall façades.

3.3.1 Dimensioning Façade Sections with Different Plan Views

Every façade section, masonry or curtain wall fits into one of three possible plan views. These are outward, inward and step. In the façade in figure 3.2, between points 2 and 3 lies an outward section. An outward section is located between the outer most ends of neighboring sections. It is like a penetration of the space enclosed into the outside. On the contrary, an inward section, in the figure between points 6 and 7, lies on the inner most ends of neighboring sections and can be visualized as a penetration of the outside into the space enclosed. Finally, a step section, in the figure between points 4 and 5, is a combination of inward and outward versions, lying between the outer most end of one neighboring section and the innermost end of another. In masonry façades determining the corresponding plan view type of a section is important as it regulates the number of joints at section ends.

3.3.1.1 Outward Masonry Façade Sections

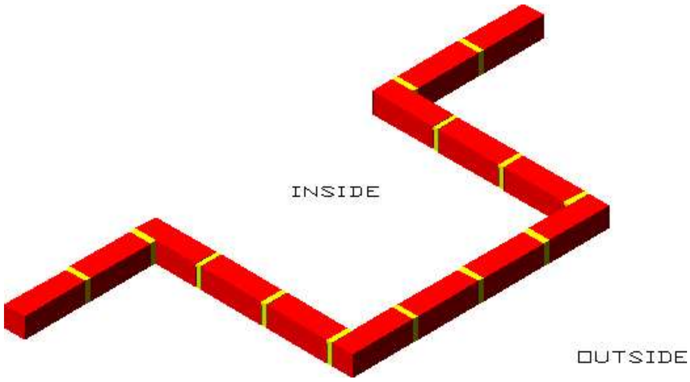


Fig 3.3: A masonry row of an outward façade section

As previously described, an outward façade section lies between two outward corners. This kind of section ends with component surfaces rather than joints. Each brick has one joint that is included in its modular dimension. When started counting from one side the joint between the first and second components would be included in the modular dimension of the first component, assuming every nth joint comes from the modular dimension of nth component, a problem arises when the last brick is reached. The joint thickness included in the last components dimension is not functional as there are no more components coming after the last brick that would jointing. Therefore when dimensioning an outward masonry section one joint thickness should be excluded;

$$= (n \times Modular\ Dimension\ of\ Component) - (1 \times Joint\ Thickness) \quad (3.2)$$

3.3.1.2 Inward Masonry Façade Sections

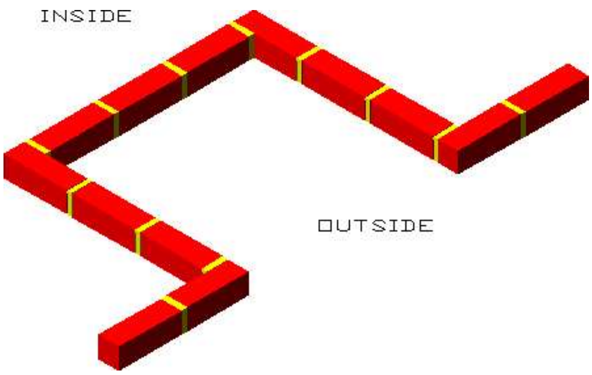


Fig 3.4: A masonry row of an inward façade section

An inward masonry section lies between two inward corners meaning it starts and ends with joints that face adjacent sections. When started counting from one side, the first joint included in the first components modular dimension, will be between this component and an adjacent wall. Every component's joint will be employed between itself and the component preceding it. If this rule is followed, when the last joint which lies between the last component and an adjacent wall is reached, the joint included in the last components modular dimension will already be used. Since there are no more components coming after the last and the adjacent section can not contribute a joint thickness to this section, while dimensioning an inward façade section an extra joint thickness must be included;

$$= (n \times Modular\ Dimension\ of\ Component) + (1 \times Joint\ Thickness) \quad (3.3)$$

3.3.1.3 Step Masonry Façade Sections

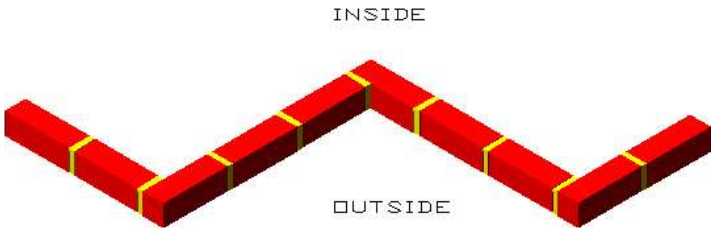


Fig 3.5: One Masonry Row of a Step Façade Section

A step façade section lies between an inward and an outward corner. It starts as an inward or outward section and ends as the other, meaning it has one end with a component surface and one end with a joint. This way there is always an equal number of components and joints, which makes step plan view types free of extra or missing joint problems faced in other versions. A step section can be dimensioned as;

$$= (n \times Modular\ Dimension\ of\ Component) \quad (3.4)$$

3.3.1.4 Curtain Wall Façade Sections

Curtain wall components are suspended in front of a structural frame through the use of anchorage points, their jointing varies according to the installation technique. Panels might be placed between vertical and horizontal framing members or in systems that don't use visible framework, gaskets fill the voids created at the intersection of panels. The mortar joints of a masonry wall are replaced by such items. The modular dimensions of a curtain wall component consist of a panel and a void dimension.

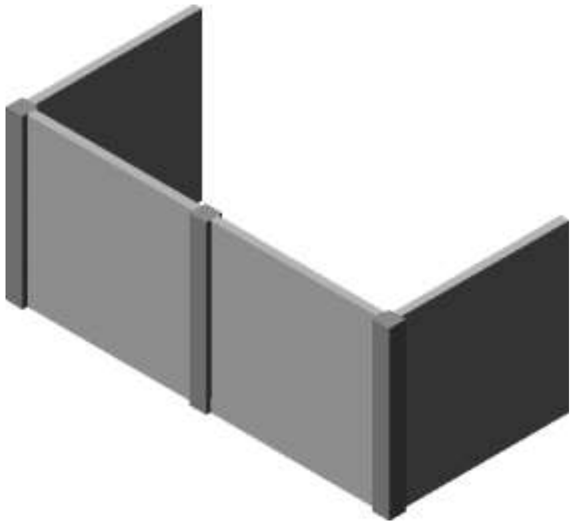


Fig 3.6: Outward Curtain Wall Section

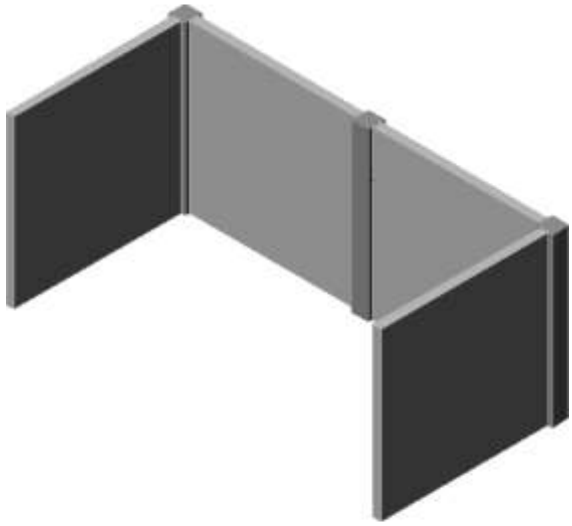


Fig 3.7: Inward Curtain Wall Section

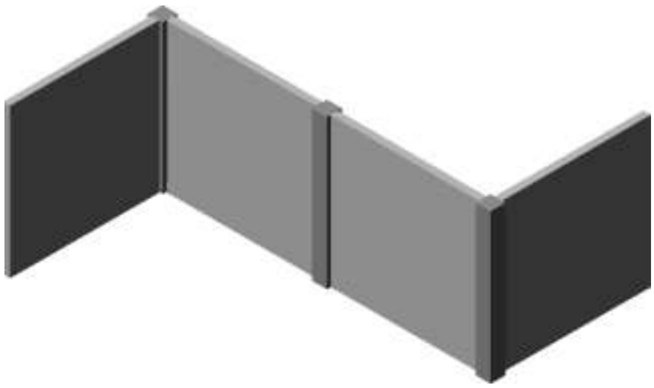


Fig 3.8: Step Curtain Wall Section

Figures 3.6 to 3.8 show outward, inward and step plan view versions of curtain wall sections. As it can be seen, unlike in masonry, curtain wall plan view versions don't have different end properties and their dimensioning can be made by a single formula. Whether, inward, outward or step, every section has n panels and n-1 voids located between these panels. On the corners, either inward or outward, the sections always end with casing, rails, framing, gaskets etc. Total section dimension is the sum of modular dimension of panels, voids and two corner elements, less one joint thickness;

$$= (n \times Modular\ Dimension\ of\ Component) - (1 \times Joint\ Thickness) + Corner\ Element\ 1 + Corner\ Element\ 2 \quad (3.5)$$

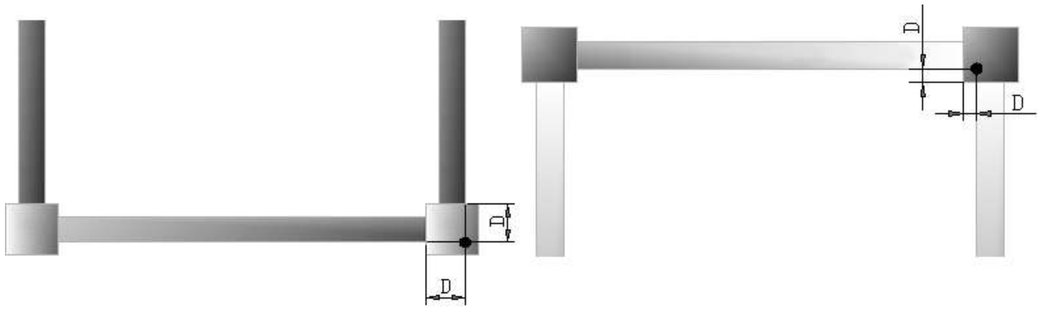


Fig 3.9: The same corner element might have different dimensional effects when placed in inward and outward corners

In dimensioning sections, rather than the whole corner element size, the part of the element that lies between the panel and the intersection point of the outer sides of the panels is taken into account. Therefore the same element might have different dimensional effects when placed in inward and outward corners, as in figure 3.9. The dimension of corner elements can be as small as zero in case of edge treated panels are used, such as in figure 3.10.

Fig 3.10: Curtain wall façade section with edge treated panels

3.3.1.5 Examples

A 700 cm long masonry façade section will be constructed using a 30 cm long component, joint thickness not included. How should the proposed section length be revised to comply with modularity requirements?

If a 1 cm thick mortar joint is used, the modular length of the component can be calculated using formula 3.1;

$$30 + 1 = 31\ cm$$

For an outward façade section, dimensioning is made using formula 3.2. When it is transformed to obtain the number of components it becomes;

$$Number\ of\ Components = \frac{Section\ Length + Joint\ Thickness}{Modular\ Dimension\ of\ Component}$$

$$n = \frac{7000mm + 10mm}{310mm} \cong 22.61$$

The result must be rounded up or down to an integer value. If 22 components are used section length would be;

$$Section\ Length = 22M - (1 \times Joint\ Thickness) = (22 \times 310) - 10 = 6810\,mm$$

If 23 components are used the section length would be;

$$Section\ Length = 23M - (1 \times Joint\ Thickness) = (23 \times 310) - 10 = 7120mm$$

The first solution requires a 2.7% reduction and the second one requires a 1.7% increase in section length which are not major adjustments. The designer can choose between these alternative whichever is applicable to the design.

For inward sections dimensioning is made using formula 3.3. When it is transformed to obtain the number of components it becomes;

$$\text{Number of Components} = \frac{\text{Section Length} - \text{Joint Thickness}}{\text{Modular Dimension of Component}}$$

$$n = \frac{7000mm - 10mm}{310mm} \cong 22.55$$

If 22 components are used section length would be;

$$Section\ Length = 22M + (1 \times Joint\ Thickness) = (22 \times 310) + 10 = 6830mm$$

If instead 23 components are used then section length would be;

$$Section\ Length = 23M + (1 \times Joint\ Thickness) = (23 \times 310) + 10 = 7140mm$$

The two solutions require a 2.4% reduction and a 2% increase in façade length respectively.

For step sections, formula 3.4 is employed. When it is transformed to obtain the number of components it becomes;

$$Number\ of\ Components = \frac{Section\ Length}{Modular\ Dimension\ of\ Component}$$

$$n = \frac{7000mm}{310mm} \cong 22.58$$

When 22 components are used section length would be;

$$Section\ Length = 22M = (22 \times 310) = 6820mm$$

When 23 components are used section length would be;

$$Section\ Length = 23M = (23 \times 310) = 7130mm$$

The first solution requires a 2.6% reduction and the second one requires a 1.9% increase in façade length.

In any version the difference between two consecutive solutions is always equal to 1M. The smaller the component is chosen to be, the smaller the increments between consecutive results will be, enabling the user to get closer to proposed dimensions.

3.3.2 Dimensioning Façade Section Heights

Dimensioning section heights is very similar to but much simpler than dimensioning plan views. Rather than corner points limiting section lengths, this time floors and ceilings regulate storey heights. Between these elements is filled with façade elements. Since every storey of a masonry building is limited from below and above, there will always be joints between end components of a course and limiting members. Therefore every storey can be considered a vertical version of an inward plan view and dimensioned the same way, by adding an extra joint thickness to a multiple of the vertical module.

In curtain walls however components surround the whole building rarely interfering with restrictions. Where section heights are equal to storey heights in a masonry building, a curtain wall section's height may be from ground level to roof. Because it is not necessary to do a calculation for every storey, it is much easier. Formula 3.5 can be employed this time using the components modular height.

3.3.3 Staggering of Masonry Rows

Components used in load bearing masonry rows must embody a certain thickness. They must also be staggered, meaning they are swayed a certain amount to the right or left of the component lying under or above them. This is caused by attaining a better load distribution and stability within the section itself or by aesthetics purposes in case of non-bearing walls where components are exposed or by bonding walls.

When considering a masonry row dimensioned as $n \times M$, this dimension includes n components and n full joints. When the row above it is being built it will be swayed to the right or the left. Because of this sway, in the row above, an end module will be moved partly out of section, and on the other end an opening will come to being which has a length equal to the length of the part of the module hanging out of the section. The part that is hanging out must be cut and the opening must be filled. Unfortunately the part that is cut can not be fitted into the opening because the opening length is also inclusive of one joint thickness. In the staggered row, the number of full modules is lessened by 1, substituted by two incomplete modules on two ends. Meanwhile the number of joints increased by 1, because of the resulting n+1 components (n-1 full and 2 partial) which necessitates n+1 joints. If for the sake of symmetry the two partial components are chosen to be equal in length, the following equation can be written;

$$1\,Component\ Length = 2\ Partial\ Component\ Lengths + 1\ Joint\ Thickness$$

$$Partial\ Component\ Length = \frac{Component\ Length\ \text{-}\ Joint\ Thickness}{2} \quad (3.6)$$

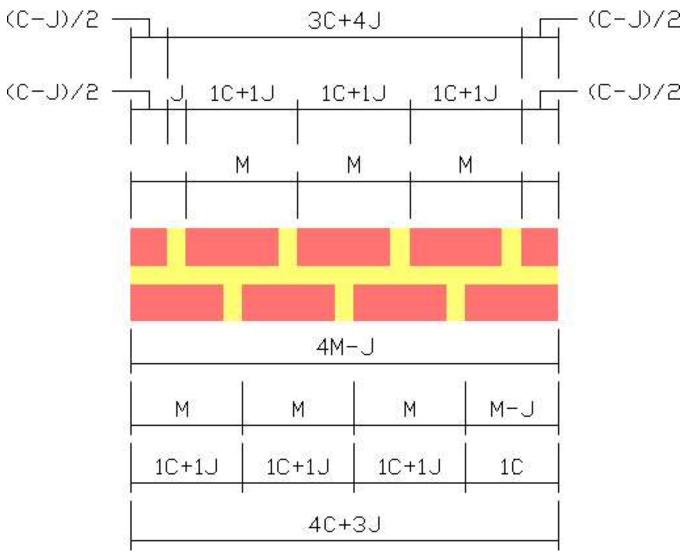
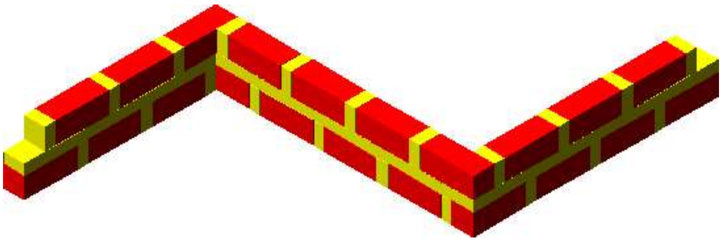


Figure 3.11: Partial component dimensions in a masonry section

The amount of stagger is equal to the length of the partial component plus one joint thickness.

$$Amount\ of\ Stagger = \frac{Component\ Length\ \text{-}\ Joint\ Thickness}{2} + Joint\ Thickness \quad (3.7)$$

Regardless of a section's dimension $(n \times M)+1\,Joint$, $(n \times M)-1\,Join$ or $n \times M$ there will always be one component missing substituted by a joint and two partial components. This makes equation 3.6 applicable to all plan views.



3.12: Step Section Stagger

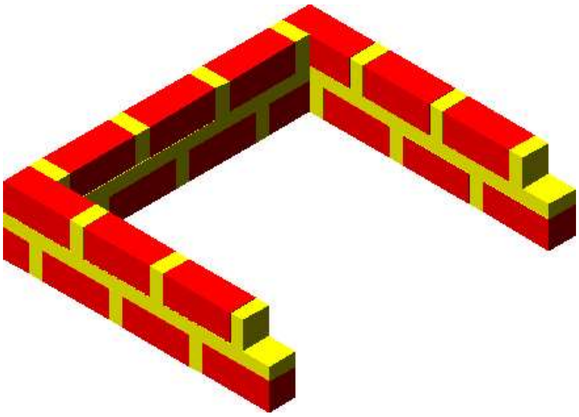


Figure 3.13: Inward Stagger

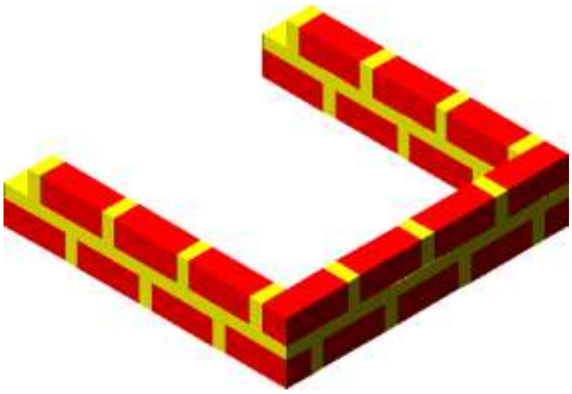


Figure 3.14: Outward Stagger

Figures 3.12 to 3.14 show the stagger of different plan view sections in 3D. In these figures it can be seen that the two partial end components are the end components of adjacent sections. What is seen as the length of the partial component from one side is actually the depth of the end component of a row from an adjacent section. It can be stated that, for achieving modularity the partial component thickness must be equal to the depth of the component. When this is substituted in formula 3.6, it becomes;

$$Component\ Depth = \frac{Component\ Length\ -\ Joint\ Width}{2} \quad (3.8)$$

Formula 3.8 shows the relation that must exist between a modular component's depth, length and joint thickness. Figures 3.15 and 3.16 show the same façade constructed using different components. The first one uses a component that complies with formula 3.8 and the second uses a component that does not. Each of the figures shows two rows that are placed on top of each other, one after another all through the section height. Both in 3.15 and 3.16 the first row requires no cutting or fitting. But only when the component in compliance with formula 3.8 is employed, the staggered second row also becomes fully modular.

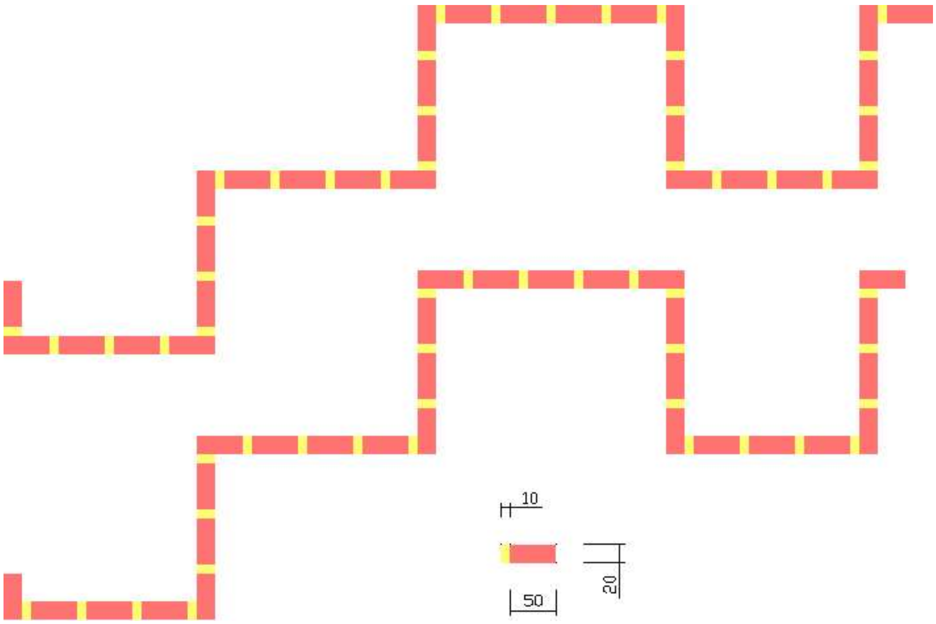


Figure 3.15: The staggered rows of a façade section require no adjustments when a component in compliance with formula 3.8 is used

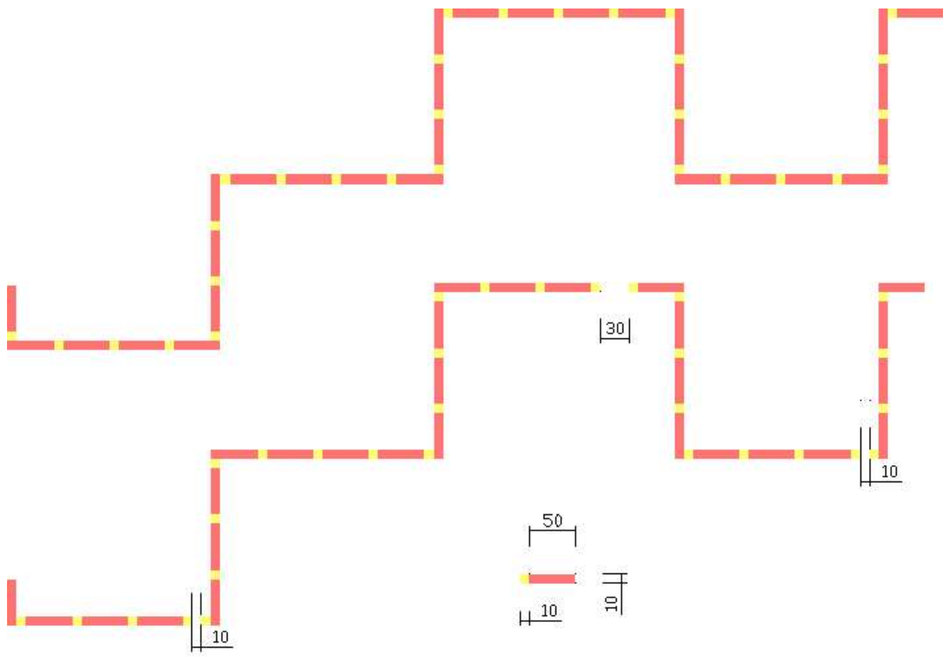


Figure 3.16: The staggered rows of a façade section require adjustments when a non modular component is used

3.3.4 Discontinuities of the Masonry

When masonry section dimensioning calculations were made in previous sections it was assumed that sections were continuous that the components did not have their courses interrupted by discontinuities, such as openings left for door, window frames or structural elements such as columns. This is a possible but rather conservative approach and almost impossible to pursue as they are spatial and structural necessities. Figure 3.17 and 3.18 show modular and non modular window openings in a façade section. Neighboring discontinuities the use of fractional components is inevitable but non modular discontinuities requires cutting of components to non modular widths shown in figure 3.17 in blue which produces material waste. In modular openings this fractional component has the same length as the partial component in a staggered row

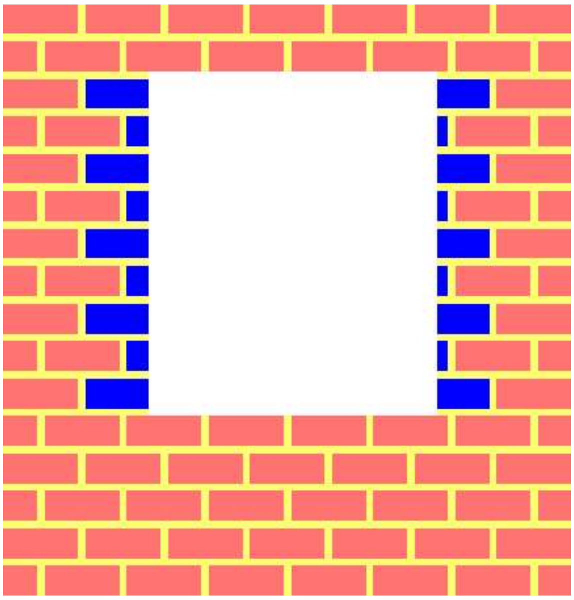


Figure 3.17: Non modular window opening in a façade

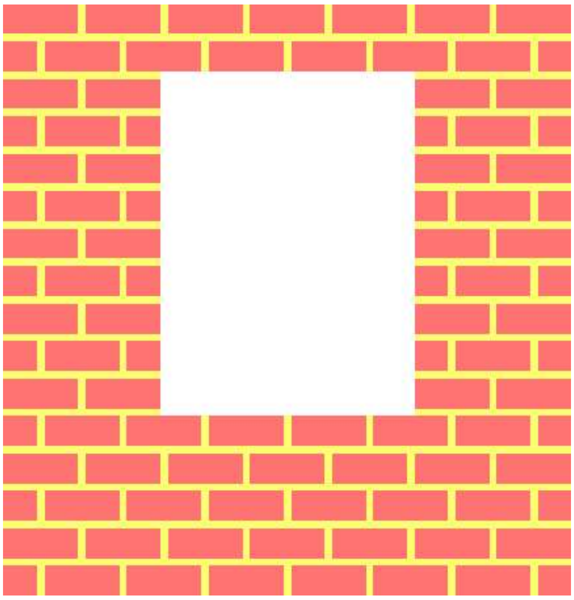


Figure 3.18: Modular window opening in a façade

Discontinuities can be divided into two groups; the first one is discontinuities that have heights shorter than section height. This group consists mainly of openings left for the placement of frames such as the window openings in figures 3.17 and 3.18.

Fig 3.19: A window frame and the opening left for its placement

Before installing a frame, an opening is prepared in the masonry. If there was no opening then instead there would be horizontal and vertical series of components. Dimensions of the openings can be derived with respect to these missing components although they are not exact multiples of the module. As seen figures 3.19 the components facing the opening are left without joints. The joint thicknesses from two sides must be included in the opening dimension. Therefore the discontinuity is dimensioned, both horizontally and vertically, as a series of components starting and ending with joints;

$$Discontinuity\ Dimension = (n \times M) + 1 \times Joint\ Thickness \quad (3.9)$$

The extra joint thickness in the opening discontinuity dimension formula is taken from the modular dimensions of the component neighboring the opening. A joint thickness must be subtracted from the modular dimension of that component in order to prevent it from being counted twice. This is solved by subtracting one joint thickness from section length and height for every opening discontinuity.

Opening discontinuities must be surrounded on all four sides by components in order to use formula 3.9 otherwise there would be no component to contribute a joint thickness. If for example more than one frame is to be placed in a single opening, then dimensioning must be made for a single discontinuity rather than as many times as the frame quantity.

The second discontinuity type consists of discontinuities that have heights equal to storey height. Columns for example are members of this group. The lengths of this discontinuity type are not subject to any limitations since there are no regulatory masonry rows above or below, but the masonry sections on the sides of the discontinuities have to be modular.

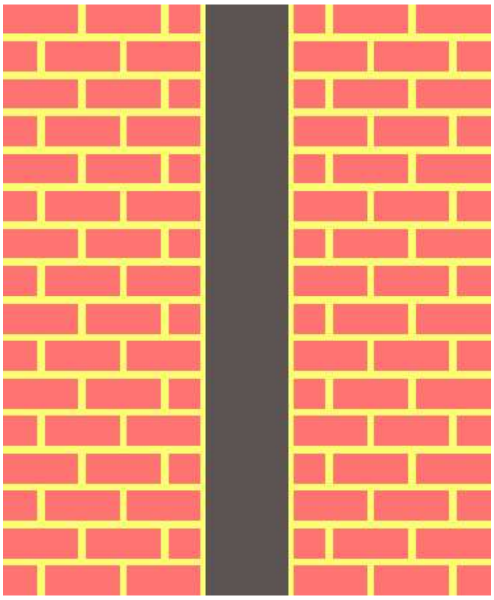


Figure 3.20: Column discontinuity in a section

Among this group, columns located on the corners require special attention because corner columns prove to be functional in some situations. In figure 3.21 are frames that correspond to corners of sections. For inward corners there is no problem; the window or door can open without any restriction. But in case a frame corresponds to an outward corner its movement is restricted by adjacent walls.

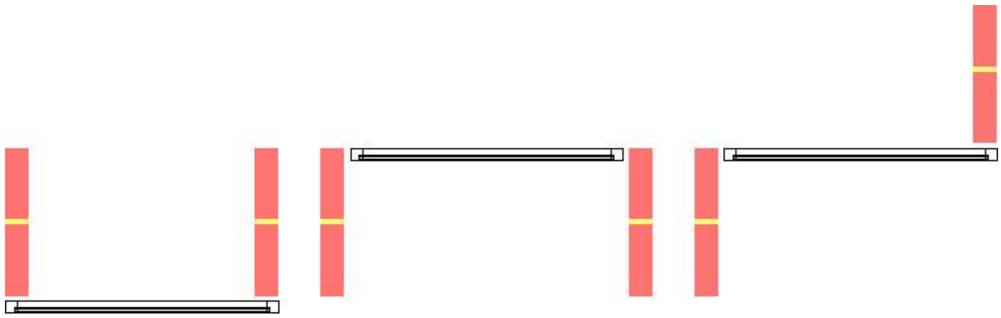


Figure 3.21: Dysfunctional window frame placement in outward section, compared to functional in inward section and partly dysfunctional in step section (from left to right)

One solution to this problem would be placing masonry components on outward corners as in figure 3.22. Also when there are corner columns on outward corners they function the same way as components.

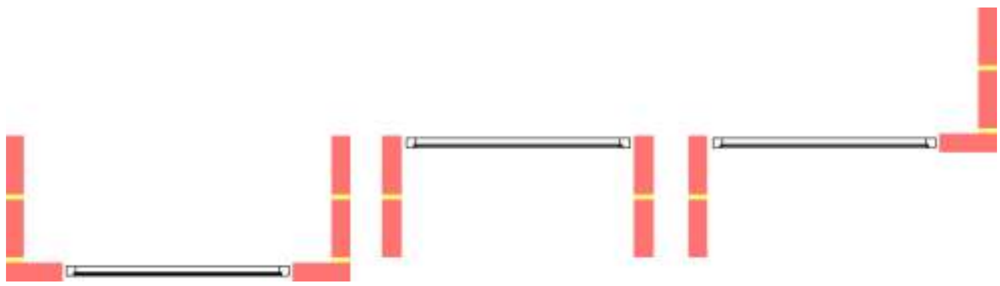


Figure 3.22: Revisions made using masonry components in outward and step sections

Another possible discontinuity of this group, internal walls intersecting with the façade are not considered as discontinuity causes. The buildings considered in this study use partition walls, plaster or plywood panels which are stabilized by studs. Load bearing internal masonry walls that penetrate into the façade and effect component alignment are not in the scope of this thesis. If masonry internal walls are wanted to be used then they can be bonded to the façade by the use of metal ties.

For dimensioning sections that contain discontinuities the following formulas are employed;

$$Section\ Length = \begin{bmatrix} (n \times Modular\ Component\ Length) \\ + Plan\ View\ Joint\ Correction \\ + (Disc._1\ Length + ... + Disc._n\ Length) \\ - (Opening\ Discontinuity\ Qty \times Joint\ Thickness) \end{bmatrix} \quad (3.10)$$

$$Section\ Height = \begin{bmatrix} (n \times Modular\ Component\ Height) + (1 \times Joint\ Thickness) \\ + (Disc._1\ Height + ... + Disc._n\ Height) \\ - (Opening\ Discontinuity\ Qty \times Joint\ Thickness) \end{bmatrix} \quad (3.11)$$

3.3.5 Using Different Components Together

The architect can choose to use a combination of different components together. In figures 3.23 and 3.24 are examples of curtains wall formed by using two differently dimensioned elements. Such arrangements of multiple components end monotony and introduce movement to the design and would be preferred when the components used will be exposed. In case of masonry the components are usually covered afterwards with paint, insulation material etc. Therefore using multiple components can be called a characteristic of curtain walls rather than masonry.

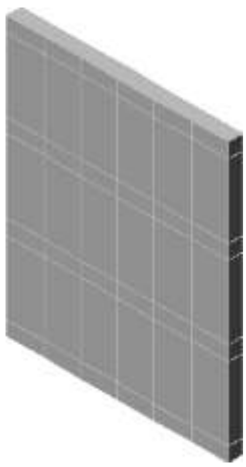


Figure 3.23: Example of a curtain wall constructed using two different components

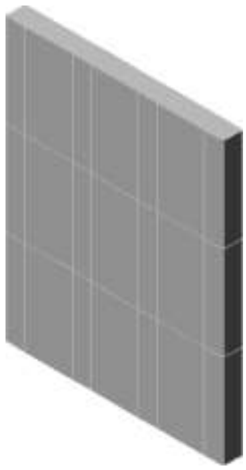


Figure 3.24: Example of a curtain wall constructed using two different components

To form a façade by using multiple components, the components must possess some dimensional relations between each other. Components coming next to one another must be of the same height where components coming under one another must be of the same width. For example in figure 3.23 there are two components forming the façade. Although the two components vary in height, they have equal widths so they are placed on top of each other forming a columnlike new module as in figure 3.25. The façade becomes a repetition of this module.

Figure 3.25: Artificial module of the curtain wall in figure 3.23

The façade in figure 3.24 again uses two components, but they are related to each other in a different way. This time the two components have equal heights but they vary in width so they are placed next to one another forming a rowlike new module as in figure 3.26. The façade becomes a repetition of this module.

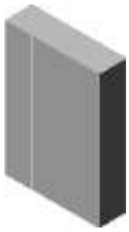


Figure 3.26: Artificial module of the curtain wall in figure 3.24

Sizes of artificial modules are computed taking into account the modular dimensions of the components forming them and then the façade dimension is calculated as a multiple of artificial module.

Much more than two differently sized components maybe used for the construction of a façade. As a result the artificial module might become a combination of many rows and columns, getting into more complicated shapes than those in figures 3.23 and 3.24. But the total module dimensions are always equal to;

$$Artificial\ \ Module\ Height = Row_1\ Height + Row_2\ Height + ... + Row_n\ Height \quad (3.12)$$

Derived from;

$$\begin{aligned} Row_1 Height &= Component_{r11} Height = Component_{r12} Height = ... \\ &= Component_{r1n} Height \end{aligned}$$

$$\begin{aligned} Row_n Height &= Component_{rn1} Height = Component_{rn2} Height = ... \\ &= Component_{rnn} Height \end{aligned} \quad (3.13)$$

Where Row_n is the nth row forming the artificial component and $Component_{rnn}$ is the modular height of the nth component of Row_n.

Also,

$$\begin{aligned} Artificial\ \ Module\ Length = Column_1\ Length + Column_2\ Length + ... \\ + Column_n\ Length \end{aligned} \quad (3.14)$$

Derived from;

$$\begin{aligned} Column_1\ Length &= Component_{c11} Length = Component_{c12} Length = ... \\ &= Component_{c1n} Length \end{aligned}$$

$$\begin{aligned} Column_n\ Length &= Component_{cn1} Length = Component_{cn2} Length = ... \\ &= Component_{cnn} Length \end{aligned} \quad (3.15)$$

Where $Column_n$ is the nth column forming the artificial component and $Component_{cnn}$ is the modular length nth component of $Column_n$.

Once the A.C. dimensions are determined section dimensions are calculated by the following formulae

$$Section\ \ Length = \begin{bmatrix} (n \times Modular\ Component\ Length) \\ -(1 \times Joint\ Thickness) \\ + Corner\ Element\ 1 + Corner\ Element\ 2 \end{bmatrix} \quad (3.16)$$

$$Section\ Height = \begin{bmatrix} (n \times Modular\ Component\ Height) \\ -(1 \times Joint\ Thickness) \\ +End\ Element\ 1 + End\ Element\ 2 \end{bmatrix} \quad (3.17)$$

3.3.5.1 Examples

A curtain wall façade section that is 12m in height and 7 m in length will be built using panels dimensioned as $(length \times height)$ $100cm \times 100cm$, $100cm \times 20cm$. A gap of 1 cm must be left between neighboring components. Corner element dimensions are equal to zero.

Panels have the same length but different heights; therefore they must be placed on top of each other. They will form an artificial component of

$$Artificial\ Component\ Height = 100 + 1 + 20 + 1 = 122cm$$

$$Artificial\ Component\ Length = 100 + 1 = 101$$

Transforming formula 3.5 the quantity of necessary A Cs along the section length is equal to,

$$= \frac{Section\ Length + 1 \times Joint\ Thickness - Corner\ Element1 - Corner\ Element2}{A.C.\ Length}$$

$$= \frac{700 + 1 - 0 - 0}{101} = 6.94$$

When 6 A Cs are used the length of the façade becomes,

$$101 \times 6 = 606$$
$$606 - 1 = 605cm$$

Or when 7 A Cs are used the length of the façade becomes,

$$101 \times 7 = 707$$
$$707 + 1 = 706cm$$

The two results require about a 13% reduction and about a 1% increase in façade length respectively.

Employing the same formula on the vertical direction, the quantity of A Cs along the section height becomes;

$$= \frac{Section\ Height + 1 \times Joint\ Thickness - Corner\ Element1 - Corner\ Element2}{A.C.\ Height}$$

$$= \frac{1200 + 1 - 0 - 0}{122} = 9.84$$

When using 9 A.Cs the section height would be,

$$(9 \times 122) - 1 = 1097cm$$

Or else when using 10 A.C.s the section height would be,

$$(10 \times 122) - 1 = 1219cm$$

These solutions require an 8.4% reduction and a 1.7% increase in section height respectively.

3.3.5.2 Prioritizing Components among Multiple Components

When employing multiple components, the designer might choose to manipulate alignment for aesthetic purposes. For example to achieve symmetry one might choose to start and end the façade using the same component. Such components are called the prioritized components. The curtain walls in figures 3.23 and 3.24 have the small component prioritized. When a component is prioritized, the façade is not an exact multiple of the artificial component.

In such cases the part that will be built using the prioritized component is separated from the part to be built using the artificial component. Separate parts are dimensioned discretely and added up afterwards. If for example in the solved example above the designer preferred to start and end the section using the smaller component the calculations would be made as follows. In the horizontal direction prioritizing a component would cause no change in the calculations because both components have the same width. In the vertical direction the modular height of the prioritized component will be subtracted from the overall section height and the rest will be dimensioned using the same artificial component height.

$$= \frac{\begin{pmatrix} Section\ Height - Height\ of\ Prioritized\ Component \\ + 1 \times Joint\ Thickness - Corner\ Element\ 1 - Corner\ Element\ 2 \end{pmatrix}}{A.C.\ Height}$$

$$= \frac{1200 - (20 + 1) + 1 - 0 - 0}{122} = 9.67$$

When using 9 and 10 ACs section heights would be 1118cm and 1240cm respectively. The results require a 6.8% reduction and a 3.3% percent increase respectively, which are different than the results without any prioritized components.

4. APPLICATION OF THE PROPOSED MODULAR FAÇADE DESIGN METHOD

A computer program is written by making use of the design method proposed in section 3. The program is written using Microsoft ® Excel and works in Microsoft ® Excel. It processes the proposed façade data employing the formulations from section 3 and as a result gives the dimensions of the closest modular façade. Rather than considering the façade as a whole, the program processes sides of a building one by one. The program is applicable to any masonry and curtain wall façade that fits into an orthogonal reference system.

Figure 4.1 is the flowchart of the program. The program has two sections. The first section is used for the design of masonry façades that employ a single component throughout the whole façade and allows for discontinuities. The second section is used for the design of curtain walls and allows for using multiple components as well as prioritizing one of them.

Both parts of the program need the following inputs; height and corner point coordinates of the proposed façade, dimensions of the component/components to be used and their jointing details. The first section also requires the quantity and dimensions of the discontinuities corresponding to sections. The second section requires choosing a prioritized component.

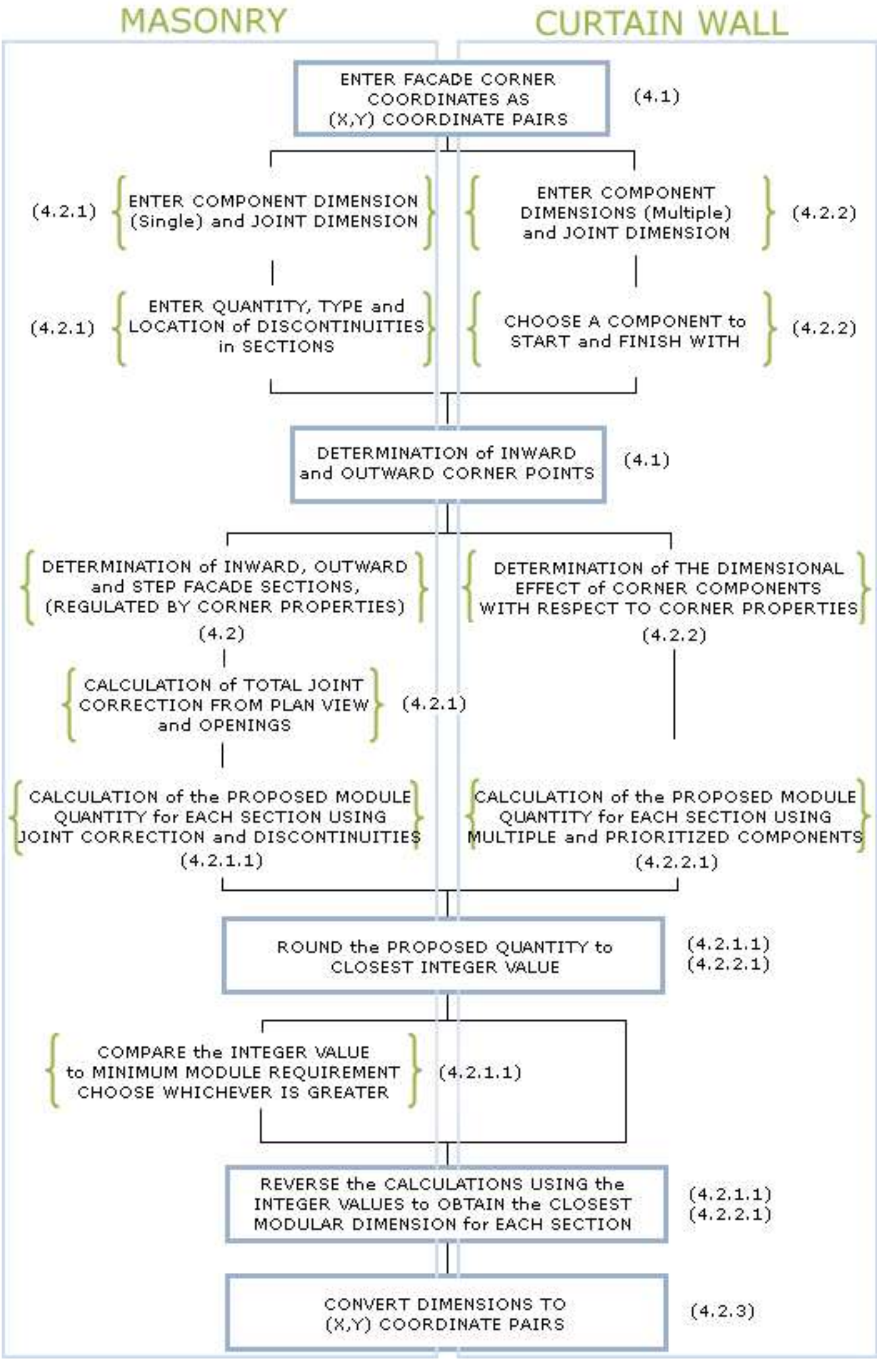


Figure 4.1: Flowchart of the program

4.1 Corner Properties of the Façade

The first step in using the program is entering the corner coordinates as (x_1, y_1), (x_2, y_2), .., (x_n, y_n). A maximum of 40 corner points may be entered. They must be entered in the order of appearance to an observer walking counterclockwise around the building. All dimensions must be in centimeters.

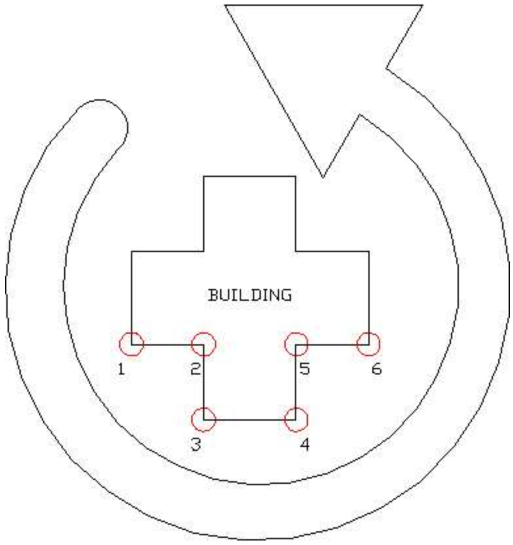


Figure 4.2: Corner coordinates must be entered in order of appearance to an observer walking counterclockwise around the building.

Coordinates of the first point have to be defined as the origin; $(x_1, y_1) = (0, 0)$. All other points' coordinates must take values relative to the first point. For example if a point is at the end of a 3.5 m long façade section that extends from the origin on the x direction, and the next point lies on the end of a 2.4 m long façade section extending on the y direction from the second point, the coordinates of these points must be entered as follows;

$$(x_1, y_1) = (0, 0)$$

$$(x_2, y_2) = (350, 0)$$

$$(x_3, y_3) = (350, 240)$$

Because of wall thicknesses, it might be confusing to determine the exact location of the corner point, whether it is located on the interior or exterior side of an external wall. Corners must always lie on the exterior of façades. A mistake changes calculations to one wall thickness.

After the corner coordinate data is collected, it is first analyzed according to the concept of plan view. As previously described in section 3.2, a façade section is an outer wall partition between two consecutive corners. To decide if a section is outward, inward or step, properties of the two corners that this section lies between are checked.

On an orthogonal plan view, an observer can see a maximum of four different corner types;

Figure 4.3: Four different corner types

According to their positioning on the sides of the building they are classified as being inward or outward.

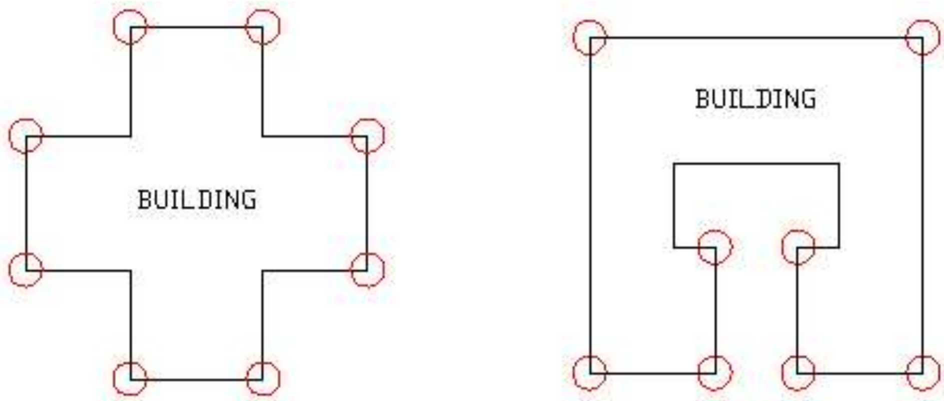


Figure 4.4: Outward corners according to their positioning on sides of the building

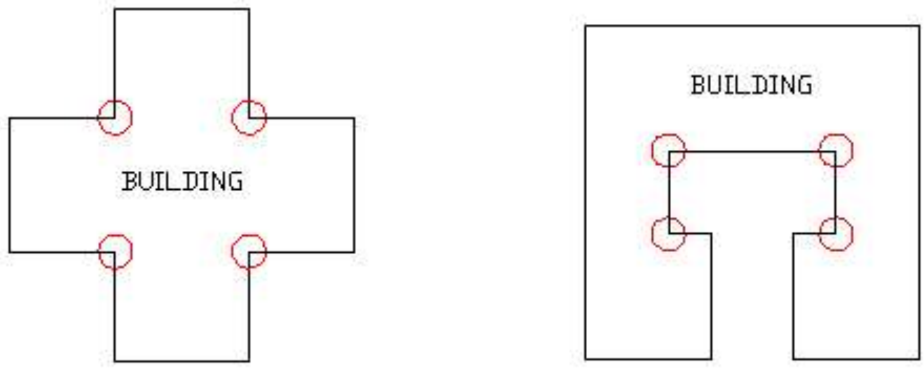


Figure 4.5: Inward corners according to their positioning on the sides of the building

As there are an infinite number of possible building plans, one might assume to encounter an infinite number of inward or outward corner versions on plans. But this is not the case. No matter how many corners a plan view may embody, there are only four inward and four outward corner versions and, any chosen corner will fit into one of these eight versions.

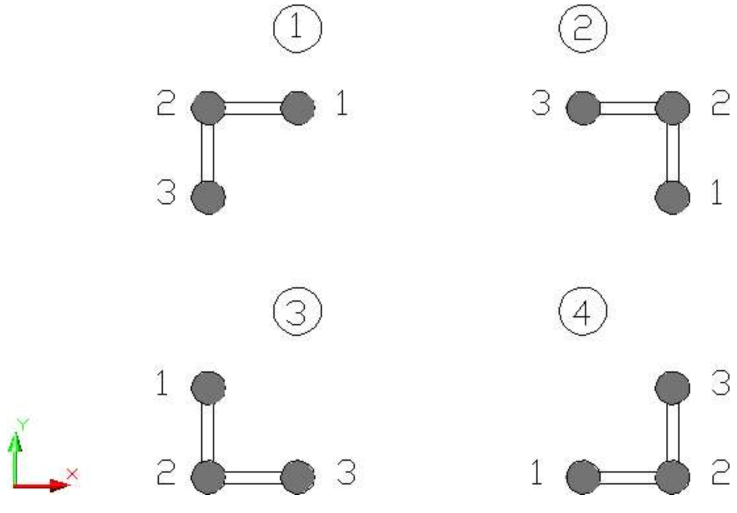


Figure 4.6: Outward corner versions according to the order of points forming them

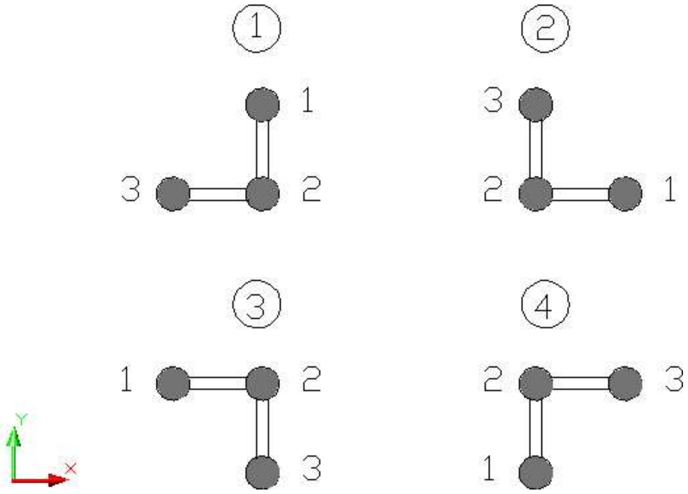


Figure 4.7: Inward corner versions according to the order of points forming them

It is possible to define these eight versions by the use of the coordinates of the three consecutive corner points forming them. In figures 4.6 and 4.7, the points forming the corners are numbered according their order of appearance to an observer walking counterclockwise around a building, the same order the user uses to enter corner coordinates to the program. In the program, for each one of the eight versions, the relations of coordinates of the three consecutive points forming such a corner are formulated. The program analyzes consecutive points in groups of three and finds the inwardness and outwardness property of corners.

4.1.1 Corner Property Formulations

In the program to identify which corner version the three point groups correspond to, coordinates of points are used. At this point four variables come into consideration, which are necessary to define the positions of the points in relation to each other;

$$\Delta x_1 = x_2 - x_1$$

$$\Delta x_2 = x_3 - x_2$$

$$\Delta y_1 = y_2 - y_1$$

$$\Delta y_2 = y_3 - y_2$$

These equations show the coordinate changes between corner forming points. Each of the eight versions have a different Δx_1, Δx_2, Δy_1 and Δy_2 value set. To find the version any corner forming three consecutive points fit into, their Δx_1, Δx_2, Δy_1 and Δy_2 values are calculated and the results are examined to find the matching corner version.

Using basic mathematics the following two relations between the points of the first outward corner version can be clearly seen;

$$x_1 > x_2 = x_3$$

$$y_1 = y_2 > y_3$$

When these are combined with the formulae above they become;

$$\Delta x_1 = x_2 - x_1 \Rightarrow \Delta x_1 < 0$$

$$\Delta x_2 = x_3 - x_2 \Rightarrow \Delta x_2 = 0$$

$$\Delta y_1 = y_2 - y_1 = 0$$

$$\Delta y_2 = y_3 - y_2 < 0$$

These formulae can be generalized as follows and it can be stated any three points in compliance with them can be classified as the first outward corner version.

$$\Delta x_{n-1} = x_n - x_{n+1} \Rightarrow \Delta x_{n-1} < 0 \quad (4.1)$$

$$\Delta x_n = x_{n+1} - x_n \Rightarrow \Delta x_n = 0 \quad (4.2)$$

$$\Delta y_{n-1} = y_n - y_{n-1} = 0 \quad (4.3)$$

$$\Delta y_n = y_{n+1} - y_n < 0 \quad (4.4)$$

Different relations exist between the coordinates of the points forming the second outward corner version, these are;

$$x_1 = x_2 > x_3$$

$$y_1 < y_2 = y_3$$

When these are applied to the Δx_1, Δx_2, Δy_1 and Δy_2 formulae become;

$$\Delta x_1 = x_2 - x_1 \Rightarrow \Delta x_1 = 0$$

$$\Delta x_2 = x_3 - x_2 \Rightarrow \Delta x_2 < 0$$

$$\Delta y_1 = y_2 - y_1 > 0$$

$$\Delta y_2 = y_3 - y_2 = 0$$

The generalized formulae for the second outward corner version are;

$$\Delta x_{n-1} = x_n - x_{n+1} \Rightarrow \Delta x_{n-1} = 0 \quad (4.5)$$

$$\Delta x_n = x_{n+1} - x_n \Rightarrow \Delta x_n < 0 \quad (4.6)$$

$$\Delta y_{n-1} = y_n - y_{n-1} > 0 \quad (4.7)$$

$$\Delta y_n = y_{n+1} - y_n = 0 \quad (4.8)$$

For the third outward corner version following relations can be directly written;

$$x_1 = x_2 < x_3$$

$$y_1 > y_2 = y_3$$

When these are applied to the Δx_1, Δx_2, Δy_1 and Δy_2 formulae they become;

$$\Delta x_1 = x_2 - x_1 \Rightarrow \Delta x_1 = 0$$

$$\Delta x_2 = x_3 - x_2 \Rightarrow \Delta x_2 > 0$$

$$\Delta y_1 = y_2 - y_1 < 0$$

$$\Delta y_2 = y_3 - y_2 = 0$$

The generalized formulae for the third outward corner version would be;

$$\Delta x_{n-1} = x_n - x_{n+1} \Rightarrow \Delta x_{n-1} = 0 \quad (4.9)$$

$$\Delta x_n = x_{n+1} - x_n \Rightarrow \Delta x_n > 0 \quad (4.10)$$

$$\Delta y_{n-1} = y_n - y_{n-1} < 0 \quad (4.11)$$

$$\Delta y_n = y_{n+1} - y_n = 0 \quad (4.12)$$

The coordinates of the points forming the fourth outward corner version have the following relations to each other;

$$x_1 < x_2 = x_3$$

$$y_1 = y_2 < y_3$$

When these are applied to the Δx_1, Δx_2, Δy_1 and Δy_2 formulae they become;

$$\Delta x_1 = x_2 - x_1 \Rightarrow \Delta x_1 > 0$$

$$\Delta x_2 = x_3 - x_2 \Rightarrow \Delta x_2 = 0$$

$$\Delta y_1 = y_2 - y_1 = 0$$

$$\Delta y_2 = y_3 - y_2 > 0$$

The generalized formulae for the fourth outward corner version are;

$$\Delta x_{n-1} = x_n - x_{n-1} \Rightarrow \Delta x_{n-1} > 0 \quad (4.13)$$

$$\Delta x_n = x_{n+1} - x_n \Rightarrow \Delta x_n = 0 \quad (4.14)$$

$$\Delta y_{n-1} = y_n - y_{n-1} = 0 \quad (4.15)$$

$$\Delta y_n = y_{n+1} - y_n > 0 \quad (4.16)$$

Between the coordinates of the first inward corner version the following relations exist;

$$x_1 = x_2 > x_3$$

$$y_1 > y_2 = y_3$$

When they are applied to the Δx_1, Δx_2, Δy_1 and Δy_2 formulae they become;

$$\Delta x_1 = x_2 - x_1 \Rightarrow \Delta x_1 = 0$$

$$\Delta x_2 = x_3 - x_2 \Rightarrow \Delta x_2 < 0$$

$$\Delta y_1 = y_2 - y_1 < 0$$

$$\Delta y_2 = y_3 - y_2 = 0$$

The generalized formulae for the first inward corner version are;

$$\Delta x_{n-1} = x_n - x_{n-1} \Rightarrow \Delta x_{n-1} = 0 \quad (4.17)$$

$$\Delta x_n = x_{n+1} - x_n \Rightarrow \Delta x_n < 0 \quad (4.18)$$

$$\Delta y_{n-1} = y_n - y_{n+1} < 0 \quad (4.19)$$

$$\Delta y_n = y_{n+1} - y_n = 0 \quad (4.20)$$

The coordinate relations of second inward corner version are as follows;

$$x_1 > x_2 = x_3$$

$$y_1 = y_2 < y_3$$

Similarly when they are used to solve the Δx_1, Δx_2, Δy_1 and Δy_2 formulae they become;

$$\Delta x_1 = x_2 - x_1 \Rightarrow \Delta x_1 < 0$$

$$\Delta x_2 = x_3 - x_2 \Rightarrow \Delta x_2 = 0$$

$$\Delta y_1 = y_2 - y_1 = 0$$

$$\Delta y_2 = y_3 - y_2 > 0$$

The generalized formulae for the second inward corner version are;

$$\Delta x_{n-1} = x_n - x_{n-1} \Rightarrow \Delta x_n < 0$$

$$\Delta x_n = x_{n+1} - x_n \Rightarrow \Delta x_n = 0$$

$$\Delta y_{n-1} = y_n - y_{n-1} = 0$$

$$\Delta y_n = y_{n+1} - y_n > 0$$

The coordinates of the points forming the third inward corner version have the following relations to each other;

$$x_1 < x_2 = x_3$$

$$y_1 = y_2 > y_3$$

When these are applied to equations Δx_1, Δx_2, Δy_1 and Δy_2 they become

$$\Delta x_1 = x_2 - x_1 \Rightarrow \Delta x_1 > 0$$

$$\Delta x_2 = x_3 - x_2 \Rightarrow \Delta x_2 = 0$$

$$\Delta y_1 = y_2 - y_1 = 0$$

$$\Delta y_2 = y_3 - y_2 < 0$$

The generalized formulae for the third inward corner version are;

$$\Delta x_{n-1} = x_n - x_{n-1} \Rightarrow \Delta x_{n-1} > 0$$

$$\Delta x_n = x_{n+1} - x_n \Rightarrow \Delta x_n = 0$$

$$\Delta y_{n-1} = y_n - y_{n-1} = 0$$

$$\Delta y_n = y_{n+1} - y_n < 0$$

The coordinates of the points forming the fourth inward corner version have the following relations to each other;

$$x_1 = x_2 < x_3$$

$$y_1 < y_2 = y_3$$

When these are applied to equations Δx_1, Δx_2, Δy_1 and Δy_2 they become

$$\Delta x_1 = x_2 - x_1 \Rightarrow \Delta x_1 = 0$$

$$\Delta x_2 = x_3 - x_2 \Rightarrow \Delta x_2 > 0$$

$$\Delta y_1 = y_2 - y_1 > 0$$

$$\Delta y_2 = y_3 - y_2 = 0$$

The generalized formulae for the fourth inward corner version are;

$$\Delta x_{n-1} = x_n - x_{n-1} \Rightarrow \Delta x_{n-1} = 0$$

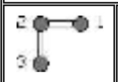
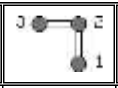
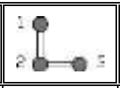
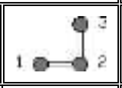
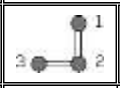
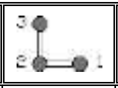
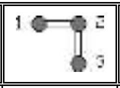
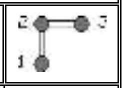
$$\Delta x_n = x_{n+1} - x_n \Rightarrow \Delta x_n > 0$$

$$\Delta y_{n-1} = y_n - y_{n+1} > 0$$

$$\Delta y_n = y_{n+1} - y_n = 0$$

The algorithms of all eight versions that are formulated above are present in the program which analyzes input coordinate data according to these formulations, and then assigns a value to every corner point.

Table 4.1: Summary of Corner Property Formulations

		Corner Versions							
		Outward				Inward			
									
Classification Data	Δx_{n-1}	<0	=0	=0	>0	=0	<0	>0	=0
	Δx_n	=0	<0	>0	=0	<0	=0	=0	>0
	Δy_{n-1}	=0	>0	<0	=0	<0	=0	=0	>0
	Δy_n	<0	=0	=0	>0	=0	>0	<0	=0

There are no other corners coming before the first and after the last corners. That being the case, for first and last corners, there is information only on two corner forming points rather than three. In section 4 it was stated that the program considers sides of the buildings separately. The end corners of a side are always outward and the program defines these two corners as outward without the need to analyze coordinate relations.

4.2 Façade Section Properties

In section 3.2 façade sections were defined as outer wall segments lying between two corners and the façade of a building was the combination of these many sections. The program dimensions sections lying between corner points separately and afterwards brings them together to find the dimensions of the façade as a whole. While dimensioning sections three different section properties are considered. First one of them is plan view of the section which regulates the number of missing or extra joints. Plan view calculations are applicable to both masonry and curtain wall façades. The second issue is the discontinuities of the masonry. This is a characteristic of masonry walls and is not considered while dimensioning curtain walls. The third issue is the dimensional and priority relations of multiple façade components, which is only applicable to curtain walls.

After each corner point is assigned an outward or inward value according to the steps explained in section 4.1.1, they are analyzed again to find out what kind of a façade section is formed between any two consecutive corners. As mentioned in sections 3.2.1.1 to 3.2.1.3, two consecutive outward corners form an outward section and two consecutive inward corners form an inward section. One inward and one outward corner form a step section regardless of the order they come in.

After the program assigns the outwardness, inwardness and stepness values to sections, it calculates the number of extra or missing joints for masonry sections. For outward sections the program gives a +1 value, for inward sections it gives a -1 value and for step sections it gives a 0 value.

Again by making use of the corner coordinates the program automatically computes necessary section properties such as length and alignment direction. Corners are points where direction of the façade sections change. Because the program solves buildings with orthogonal plan views, sections can only lie along two directions which are perpendicular to each other namely, x and y directions. If before a specific corner point the section lies along the x direction, then the section after that point always lies along the y direction or vice versa. If a section lies along the x direction then the x coordinates of the two corner points will be different but y coordinates will be the same, if a section lies along the y direction then it is the other way round. By checking this relation between consecutive points the program calculates the proposed length of sections and also the direction which the sections lie along.

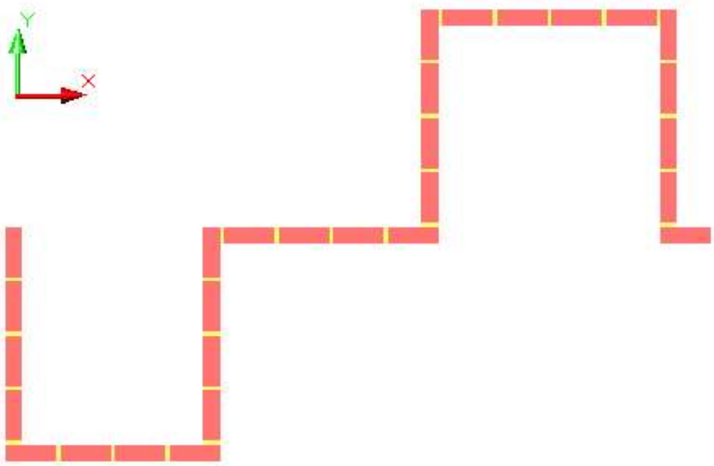


Figure 4.8: Corners and façade sections in relation to x-y coordinate system

4.2.1 Masonry Façade Section Properties

The first part of the program is used in solving masonry façades. After the determination of the plan view properties, the major issue in masonry section dimensioning is the discontinuities. The user is asked to enter the quantity and dimensions of discontinuities in the spaces provided for each section. In the program many possible causes of discontinuities are defined. The first one is opening type discontinuities with heights shorter than section heights. For each section the user may enter the dimensional properties and occurrence quantity of three of this type of discontinuities. The second one is column type discontinuities with heights equal to section height. The user may enter the length and occurrence quantity of one discontinuity belonging to this group. Because of reasons explained in section 3.2.4 the height of this type of discontinuities are not required. There is also a third discontinuity type which is for corner columns. For each section the user can enter two discontinuities of this type, one for every corner. Again for corner columns height is not required.

The program considers discontinuities as coming next to each other on the plan view, rather than on top of each other. They must be located so that on any vertical cross-section only one discontinuity may exist and there is at least one horizontal cross-section where all discontinuities coexist. On the horizontal direction, the program dimensions this specific cross-section.

Dimensions of the horizontal and vertical modules are calculated by the program according to the component and joint dimensions entered by the user. The length, depth and joint size of the chosen component must comply with formula 3.8, its height is not subject to any limitation. When sections contain discontinuities, for the whole section to be modular, dimensions of the discontinuities must comply with modularity principles stated in section 3.2.4 as well as the component. For opening discontinuities the heights and lengths must comply with formula 3.9. Column type discontinuities are not subject to any dimensional limitations but the user must keep in mind that a corner column located on an outward corner has two sides visible on two sections; such a column's data must be entered to all sections it affects.

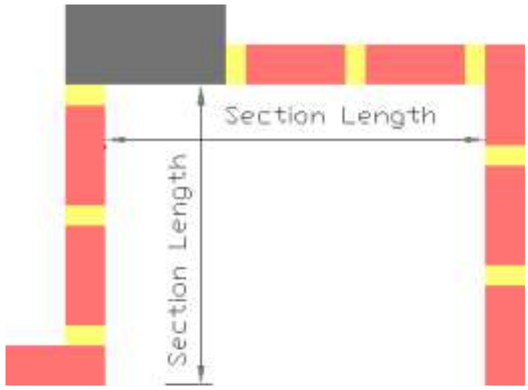


Figure 4.9: A corner column located on an inward corner effects the dimensioning of only one section

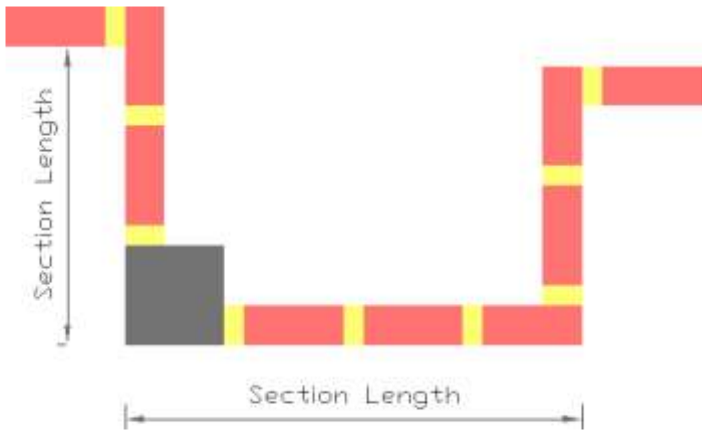


Figure 4.10: A corner column located on an outward corner effects the dimensioning of two sections

The program controls if input heights and lengths fulfill the requirements. It does not accept discontinuity dimensions that are not in compliance with dimensional limitations. Modular calculator section of the program aids users on finding these values. This section calculates acceptable discontinuity heights and lengths with respect to façade component dimensions entered by the user.

Opening discontinuities include one extra joint in their dimensions. These are actually taken from the modular dimension of a component and included in the opening dimension. If the modular dimension of the component is used along with the opening then joint quantity would be doubled. To balance this, while dimensioning the program gives a -1 joint correction value for each opening discontinuity. These joint corrections are added up and then multiplied by the joint thickness and subtracted from the total length to acquire modularity.

As stated in section 3.2.4 opening discontinuities must be surrounded on all four sides with components. To achieve this, the program ensures the placement of at least one component between adjacent discontinuities of any section. If the user wants to place multiple doors, windows or any combination of such elements in a single opening, meaning all elements will be in contact with one another, a single length calculated as the sum of all these elements must be used. This symbolic length itself must comply with the dimensioning principles. The length of each frame, consisting of their own dimension and one joint, must be dimensioned as $n \times M$. The height of each frame must fulfill opening discontinuity dimensional requirement and must be handled separately.

As thoroughly explained in section 3.2.4 discontinuities neighboring adjacent sections might result in dysfunctional door or window frames. To solve this, the program checks to see the nature of the corners forming each section. In case any of them happens to be outward, the program controls the quantity of façade components or outward corner columns. If the sum of the outward corner columns and façade components is less than the quantity of outward corners, the program calculates the extra façade components necessary to compensate this missing quantity to acquire proper functioning of the frames.

4.2.1.1 Dimensioning Masonry Façades Using the Program

The program first performs the horizontal dimensioning. To begin with, the total joint correction caused by both the plan view and the discontinuities is calculated.

$$= \textit{Total Joint Correction}$$
$$= (\textit{J.C. From Plan View} + \textit{J.C. From Opening Discontinuities}) \times \textit{Joint Thickness}$$

$$= \left[(+1,0,-1) + (-1 \times (\textit{Opening Discontinuity Quantity})\right] \times \textit{Joint Thickness}$$

After the completion of this step, the program subtracts the total joint correction and the sum of all discontinuity lengths from the proposed section length. The result is divided by the modular component length to find the number of components necessary to arrive at the proposed dimension.

$$= \textit{Proposed Horizontal Component Quantity}$$

$$= \frac{\begin{array}{c}\textit{Proposed Façade Length - T.J.C.-} \\ \textit{(Disc.}_1 \textit{ Length} \times \textit{Disc.}_1 \textit{ Qty.} + ... + \textit{Disc.}_n \textit{ Length} \times \textit{Disc.}_n \textit{ Qty.)}\end{array}}{\textit{Modular Component Length}}$$

If the result from this calculation is an integer then the proposed dimension is already modular. If the result is not an integer for example if it is 3.6, it means more than 3 and less than 4 components are needed, in other words the 4th component has to be cut to its 6/10 to make it fit the space available. This number is rounded up and down to the closest integers which gives two possible solutions, to find the optimum they are compared to the decimal result from the formula, whichever is closest will be considered as the best solution. This result is then compared to the minimum module requirement which is the sum of compulsory modules, between neighboring openings and between openings and adjacent sections. If the closest integer result from the formula is less than minimum module requirement then section dimensioning is made according to minimum module requirement if not it is made according to the closest integer result. Once the result is obtained, the process is reversed by multiplying the result with the modular component length, then adding discontinuity dimensions and joint corrections. The result is the modular length closest to the proposed section size.

In vertical modular dimensioning the same steps are followed. Again the first step is joint correction. Since all sections act as inward on the vertical direction the joint correction caused by this property is +1 for every section. In vertical modular dimensioning only opening discontinuities are taken into account as column discontinuity heights are equal to section height. There can be many opening discontinuities in a section but as stated before the program allows only one discontinuity on any vertical cross-section of a façade section. Therefore the calculations are repeated for each section as many times as the opening discontinuity quantity using the following formula;

$$= \textit{Proposed Vertical Component Quantity}$$

$$= \frac{\textit{Proposed Façade Height} + 1 \times \textit{Joint Thickness)} - \textit{Opening Disc.}_1\ \textit{Height}}{\textit{Modular Component Height}}$$

On the vertical direction there is no minimum module quantity and no comparison is required. The results are rounded up and down to closest integer values then they are converted to section heights by reversing the process. Among all sections and discontinuities, the discontinuity that requires the largest section height is chosen. The two results found for this discontinuity are compared to the proposed storey height. The closest becomes the height of all sections namely the storey height. The amount of stagger is calculated by the program according to formula 3.7.

4.2.2 Curtain Wall Façade Section Properties

The second part of the program solves curtain walls constructed using one, two or four differently sized components. In addition to corner coordinates, the program requires the user to enter the quantity of components to be used, their dimensions and prioritize one of them. For a section employing only one component there can be no prioritized component.

As mentioned in section 3.2.5, when multiple components are used, they must be related to each other dimensionally. For example when two components are used they must have equal heights or widths. If instead four different components are used in total they must give two different heights and two different widths.

Table 4.2: Possible dimensional relations between two components to be used in a single façade

Component	Height of Component	Length of Component
1	$Height_1$	$Length_1$
2	$Height_1$	$Length_2$

Table 4.3: Possible dimensional relations between two components to be used in a single façade

Component	Height of Component	Length of Component
1	$Height_1$	$Length_1$
2	$Height_2$	$Length_1$

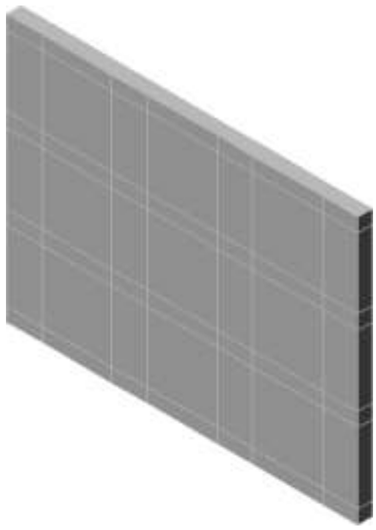


Figure 4.11: A curtain wall façade section constructed using four different components

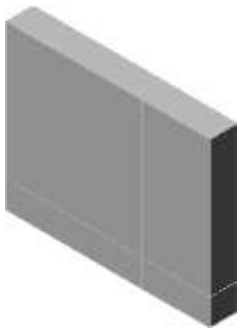


Figure 4.12: Artificial module of the multiple element curtain wall façade in figure 4.11

Table 4.4: Dimensional relations between four components to be used in a single façade

Component	Height of Component	Length of Component
1	$Height_1$	$Length_1$
2	$Height_1$	$Length_2$
3	$Height_2$	$Length_1$
4	$Height_2$	$Length_2$

The program first checks to see if the input components are related to each other as stated in tables 4.2 to 4.4. If the inspection result is satisfactory, the program computes the dimensions of the artificial module by placing components of the same height next to one another and components of the same length under one another using formulae 4.12 to 4.15. For a section employing only one component no artificial component is formed.

The jointing details between different components or between components of the same kind must be entered as well as the dimensions of any special horizontal and vertical end component which might be required by the chosen installation technique.

4.2.2.1 Dimensioning Curtain Wall Façades Using the Program

After the artificial component size is calculated, dimensions of the end components and prioritized component dimension are subtracted from the proposed section height and length. The remaining height and length are divided by the artificial components height and length respectively to find the component quantity necessary to achieve the proposed dimension.

$$= \textit{Proposed Component Quantity}$$

$$= \frac{\begin{pmatrix} \textit{Proposed Façade Dimension} + (1 \times \textit{Joint Thickness}) \\ \textit{- Corner Element 1 - Corner Element 2} - \textit{Prioritized Component Dimension} \end{pmatrix}}{\textit{Artificial Component Dimension}}$$

If the result from this calculation is an integer then the proposed dimension is already modular. If the result is not an integer then it is rounded up and down to the closest integers which gives two possible solutions, to find the optimum they are compared to the decimal result from the formula, whichever is closest will be considered as the best solution. Once the result is obtained, the process is reversed by multiplying the result with the modular component length, then adding discontinuity dimensions and joint corrections. The result is the modular length closest to the proposed section size

4.2.3 The Results

After optimum modular dimensions are calculated for every section, dimensions are converted to coordinates, just like the user enters data. The first point always has the coordinates (0, 0). Then the program checks to see if the first section lies in the x or the y direction. For a section that lies along the x direction, the coordinates of the two end points have the following relations to each other $\Delta x \neq 0$ and $\Delta y = 0$ then section dimension is demonstrated as an increase or decrease equal to Δx from the x coordinate value of the first point to the x coordinate value of the second point. For a façade section that lies along the y direction, between the coordinates of the two end points the following relations exist $\Delta x \neq 0$ and $\Delta y = 0$ then the section dimension is demonstrated as an increase or decrease equal to Δy from the y coordinate value of the first point to the y coordinate value of the second point. Whether there will be an increase or decrease is decided by checking the coordinate relations of the proposed façade section corners. The same process is repeated for every section until the coordinates of the last corner point are reached. Figure 4.13 shows the relations between section dimensions and corner point coordinates.

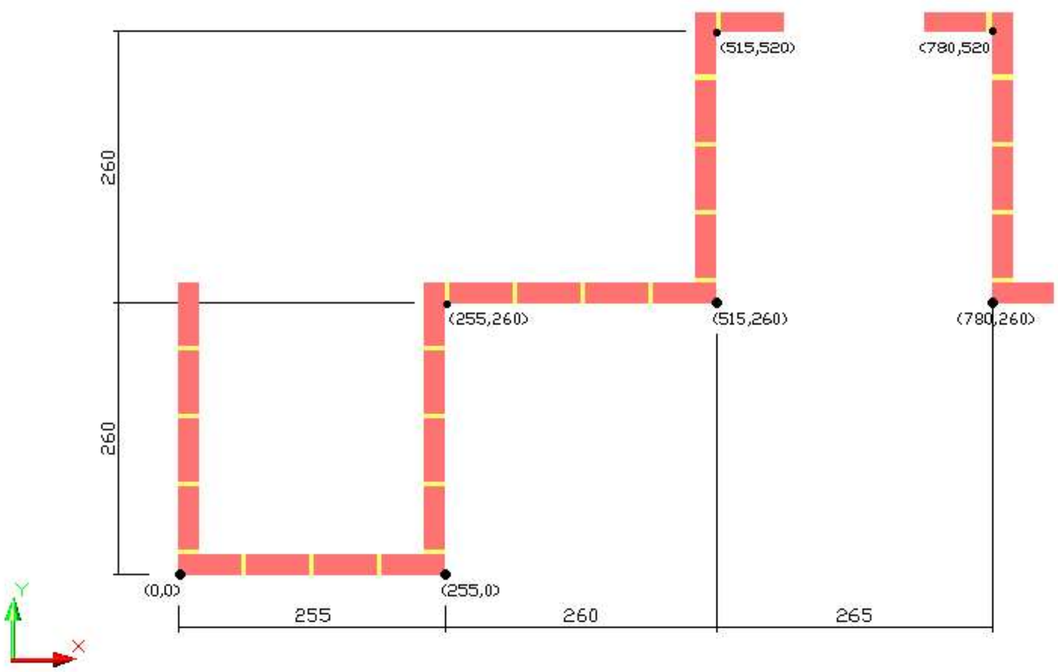


Figure 4.13: Section dimensions converted to corner coordinates

As the result of this process the whole façade can be demonstrated as corner points. The user can see the revised locations of the points entered in the beginning. In the results page of the program, section details including length, height, discontinuity dimensions and quantities are summarized along with the proposed and suggested corner coordinates.

4.3 Solved Examples

This section consists of masonry and curtain wall façade dimensioning examples. All examples are solved using the computer program developed as a part of this study. Steps from entering data to the results report are explained in detail.

4.3.1 Masonry façades

In this section a masonry façade consisting of eight corner points and seven sections which embody all three different plan view types, is solved four times each time with different section properties. In the first problem a continuous section is solved, in the second sections contain opening discontinuities, in the third sections contain column discontinuities and in the last problem opening and column discontinuities coexist.

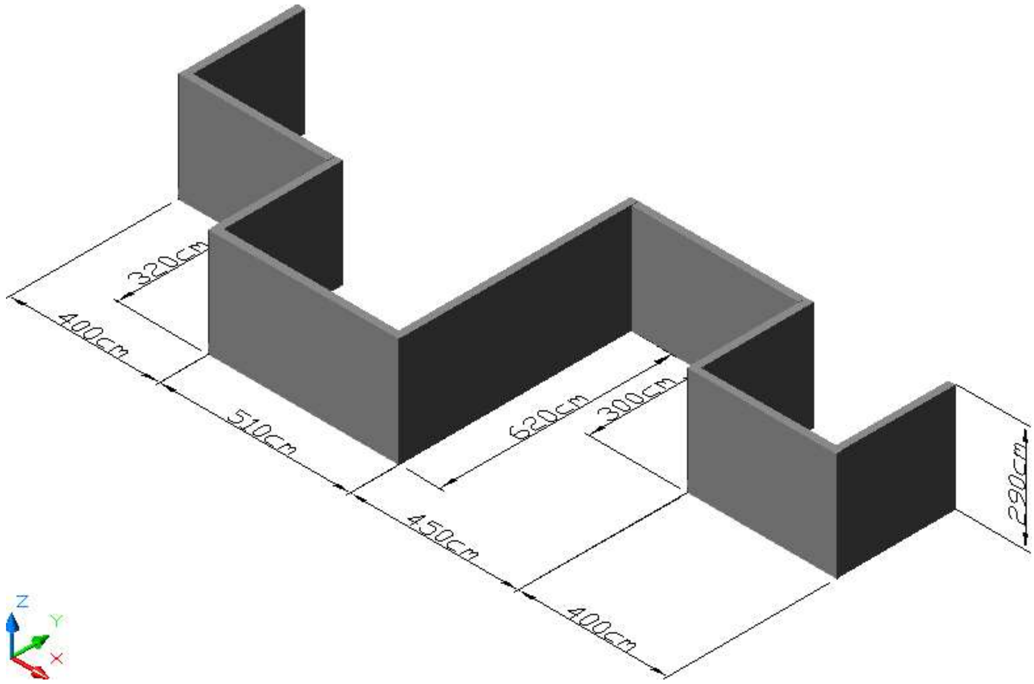
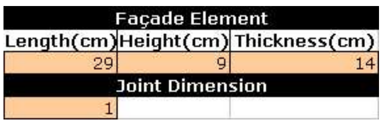


Figure 4.14: Proposed masonry façade to be solved by the program

In all examples a brick component dimensioned as $29cm \times 9cm \times 14cm$ ($length \times height \times width$) is used which is in accordance with formula 3.8 when a joint width of 1cm is employed.



Façade Element		
Length(cm)	Height(cm)	Thickness(cm)
29	9	14
Joint Dimension		
1		

Figure 4.15: Component properties

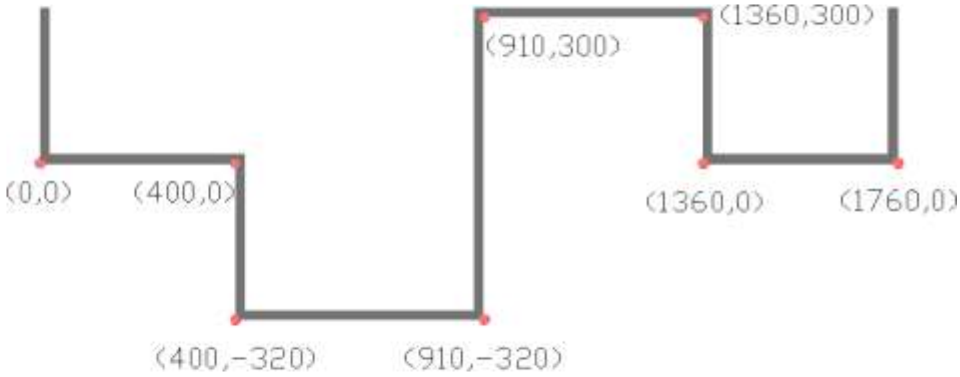


Figure 4.16: Corners coordinates of the proposed façade

The coordinates of the eight corners of the proposed façade are the same for all examples. The program calculates the Δx_1, Δx_2, Δy_1 and Δy_2 values and classifies corners as inward or outward according to table 4.1. The results are as follows;

Pt	X	Y	Δx1	Δy1	Δx2	Δy2	Corner
1	0	0					Outward
2	400	0	400	0	0	-320	Inward
3	400	-320	0	-320	510	0	Outward
4	910	-320	510	0	0	620	Outward
5	910	300	0	620	450	0	Inward
6	1360	300	450	0	0	-300	Inward
7	1360	0	0	-300	400	0	Outward
8	1760	0	400	0	0	0	Outward

Figure 4.17: Corner properties calculated by the program

Between these eight points there is a total of seven sections. The program calculates the lengths and alignment direction of these sections. Also by making use of the corner properties, the program determines plan view type and calculates the corresponding plan view joint correction.

Section	|Δ|	Direction	Plan
1-2	400	X	0
2-3	320	Y	0
3-4	510	X	-1
4-5	620	Y	0
5-6	450	X	+1
6-7	300	Y	0
7-8	400	X	-1

Figure 4.18: Section dimension, alignment direction and plan view joint correction of the proposed façade calculated by the program

Looking at the results it can be said that sections 3-4, 7-8 are outward, section 5-6 is inward and all other sections are step. From this point onward calculations differ for different examples.

4.3.1.1 Masonry Façade Example with No Discontinuities

In this first example there are no discontinuities throughout the sections. Component quantity calculations are made according to formulae 3.10 and 3.11. Staggering is calculated by the program according to formula 3.7. Parts of the formulae regarding discontinuities are equal to zero. The required horizontal and vertical component quantities for the proposed façade, the closest integer quantities to these values and corresponding lengths and heights for the integer values are calculated by the program. All data and the percentage of change between the proposed and suggested section dimensions are summarized at the section details part of the results page. Horizontal dimensions are converted to coordinates and are presented along with the proposed coordinates at the corner coordinates part of the results page.

Section	Quantity Check
1-2	13,3333
2-3	10,6667
3-4	17,0333
4-5	20,6667
5-6	14,9667
6-7	10,0000
7-8	13,3667

Figure 4.19: Proposed horizontal module quantity

SECTION DETAILS

Section	Module Qty	Joint Correction	Op. 1 (cm)	Op. 2 (cm)	Op. 3 (cm)	Column Disc. (cm)	CC 1st Pt. (cm)	CC 2nd Pt. (cm)	Result Dim. (cm)	Proposed Dim. (cm)	Revision %
1-2	13	0	-	-	-	-	-	-	390	400	-2,5%
2-3	11	0	-	-	-	-	-	-	330	320	3,1%
3-4	17	-1	-	-	-	-	-	-	509	510	-0,2%
4-5	21	0	-	-	-	-	-	-	630	620	1,6%
5-6	15	1	-	-	-	-	-	-	451	450	0,2%
6-7	10	0	-	-	-	-	-	-	300	300	0,0%
7-8	13	-1	-	-	-	-	-	-	389	400	-2,8%

CORNER COORDINATES

CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y
1	0	0	0	0
2	400	0	390	0
3	400	-320	390	-330
4	910	-320	899	-330
5	910	300	899	300
6	1360	300	1350	300
7	1360	0	1350	0
8	1760	0	1739	0

SUGGESTION Z		
qty.	cm	revision
28	281	-3,1%
-	-	-
STAGGERING		
15 cm		

Figure 4.20: Horizontal and vertical section details, corner coordinates and amount of stagger suggested by the program

Appendix 1a and 1b are the plan view and elevation drawings of the results of this example.

4.3.1.2 Masonry Façade Example with Door and Window Openings

In this example, two opening discontinuities are placed in three sections. Each one of these three sections has a different plan view type. Dimensions of the discontinuities are from the module calculator, which is a list of horizontal and module multiples in compliance with opening dimension formula 3.8.

HORIZONTAL MODULE (cm)		VERTICAL MODULE (cm)	
1 M	**30**	**1 M**	**10**
1 M+Joint	31	1 M+Joint	11
2 M+Joint	61	2 M+Joint	21
3 M+Joint	91	3 M+Joint	31
4 M+Joint	121	4 M+Joint	41
5 M+Joint	151	5 M+Joint	51
6 M+Joint	181	6 M+Joint	61
7 M+Joint	211	7 M+Joint	71
8 M+Joint	241	8 M+Joint	81
9 M+Joint	271	9 M+Joint	91
10 M+Joint	301	10 M+Joint	101

Figure 4.21: Module calculator

	Opening Discontinuity 1			Opening Discontinuity 2		
Section	Qty. of Discontinuity 1 in Section	Length (cm)	Height (cm)	Qty. of Discontinuity 2 in Section	Length (cm)	Height (cm)
1-2	2	91	121			
2-3						
3-4	2	91	121			
4-5						
5-6	1	91	121	1	151	221
6-7						
7-8						

Figure 4.22: Opening discontinuity inputs

The program calculates the proposed quantities employing formulae 3.10 and 3.11. In this example joint corrections also come from opening discontinuities. Because of the openings there is also a minimum module quantity requirement on the horizontal direction. As explained in section 4.2.1, first of them is caused by the placement of at least one module between neighboring openings and the second is caused by the module requirement in outward corners for proper frame functioning. Minimum module quantity is compared to the result from formula 3.10 whichever is greater becomes the suggested quantity.

Section	Direction	Opening	Plan	Total	Quantity Check	Discontinuity Requirements	Plan Requirements
1-2	X	-2	0	-2	7,3333	1	1
2-3	Y	0	0	0	10,6667	0	0
3-4	X	-2	-1	-3	11,0333	1	2
4-5	Y	0	0	0	20,6667	0	0
5-6	X	-2	+1	-1	6,9667	1	0
6-7	Y	0	0	0	10,0000	0	0
7-8	X	0	-1	-1	13,3667	0	0

4.23: Proposed horizontal quantity and minimum module requirements

SECTION DETAILS

Section	Module Qty	Joint Correction	Op. 1	Op. 2	Op. 3	Column Disc.	CC 1st Pt.	CC 2nd Pt.	Result Dim.	Proposed Dim.	Revision %
			(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	
1-2	7	-2	91	-	-	-	-	-	390	400	-2,5%
2-3	11	0	-	-	-	-	-	-	330	320	3,1%
3-4	11	-3	91	-	-	-	-	-	509	510	-0,2%
4-5	21	0	-	-	-	-	-	-	630	620	1,6%
5-6	7	-1	91	151	-	-	-	-	451	450	0,2%
6-7	10	0	-	-	-	-	-	-	300	300	0,0%
7-8	13	-1	-	-	-	-	-	-	389	400	-2,8%

CORNER COORDINATES

CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y
1	0	0	0	0
2	400	0	390	0
3	400	-320	390	-330
4	910	-320	899	-330
5	910	300	899	300
6	1360	300	1350	300
7	1360	0	1350	0
8	1760	0	1739	0

SUGGESTION Z		
qty.	cm	revision
28	281	-3,1%
-	-	-
STAGGERING		
15 cm		

4.24: Horizontal and vertical section details, corner coordinates and amount of stagger suggested by the program

Suggested dimensions are the same as of previous example but the module quantity is different because some modules are replaced by openings. Appendix 1c and 1d are the plan view and elevation drawings of the results of this example.

4.3.1.3 Masonry Façade Example with Column Discontinuities

In the third example sections contain column discontinuities. Their dimensions are not limited and they do not affect the modularity of sections. A group of three columns, one midway column and two corner columns, are placed in three sections. Each one of the three sections has a different plan viewtype. Columns on outward corners affect two sections.

	Column Discontinuity		Corner Columns					
Section	Qty. of Column	Length (cm)	Pt	Section	Length (cm)	Pt	Section	Length (cm)
			1			1	1-2	30
1-2	1	35	2	1-2	25	2	2-3	
2-3			3	2-3	30	3	3-4	25
3-4	1	20	4	3-4	25	4	4-5	30
4-5			5	4-5		5	5-6	45
5-6	1	20	6	5-6	20	6	6-7	
6-7			7	6-7		7	7-8	
7-8			8	7-8		8	8-9	

Figure 4.25: Column discontinuity inputs

Section	Direction	Disc.	Plan	Total	Quantity Check	Discontinuity Requirements	Plan Requirements
1-2	X	0	0	0	10,2667	2	0
2-3	Y	0	0	0	9,6333	0	0
3-4	X	0	-1	-1	14,6000	2	0
4-5	Y	0	0	0	19,6333	0	0
5-6	X	0	+1	1	12,1000	2	0
6-7	Y	0	0	0	10,0000	0	0
7-8	X	0	-1	-1	13,3667	0	0

Figure 4.26: Proposed horizontal module quantity and minimum module requirements

Since there are no openings there is no minimum module requirement for placement on outward corners but a midway column must be placed between two modules on two sides to distinguish it from a corner column. Minimum module requirements are already satisfied by dimensional requirements and the results are as follows;

SECTION DETAILS

Section	Module Qty	Joint Correction	Op. 1	Op. 2	Op. 3	Column Disc.	CC 1st Pt.	CC 2nd Pt.	Result Dim.	Proposed Dim.	Revision %
			(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	(cm)	
1-2	10	0	-	-	-	35	30	25	392	400	-2,0%
2-3	10	0	-	-	-	-	-	30	331	320	3,4%
3-4	15	-1	-	-	-	20	25	25	522	510	2,4%
4-5	20	0	-	-	-	-	30	-	631	620	1,8%
5-6	12	1	-	-	-	20	45	20	447	450	-0,7%
6-7	10	0	-	-	-	-	-	-	300	300	0,0%
7-8	13	-1	-	-	-	-	-	-	389	400	-2,8%

CORNER COORDINATES

CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y
1	0	0	0	0
2	400	0	392	0
3	400	-320	392	-331
4	910	-320	914	-331
5	910	300	914	300
6	1360	300	1361	300
7	1360	0	1361	0
8	1760	0	1750	0

SUGGESTION Z		
qty.	cm	revision
28	281	-3,1%
-	-	-
STAGGERING		
15 cm		

Figure 4.27: Horizontal and vertical section details, corner coordinates and amount of stagger suggested by the program

The height of sections is the same as in previous examples but the use of non modular column discontinuities has changed section lengths. This however does not affect the efficiency of the system as masonry sections on the sides of the columns are still modular. Appendix 1e and 1f are the plan view and elevation drawings of the results of this example.

4.3.1.4 Masonry Façade Example with Both Opening and Column Discontinuities

In this example a combination of the opening and column discontinuities from the previous two examples are placed in three sections, each of which have a different plan view type.

	Opening Discontinuity 1			Opening Discontinuity 2			Column Discontinuity		Corner Columns					
Section	Qty.	Length (cm)	Height (cm)	Qty.	Length (cm)	Height (cm)	Qty. of Column	Length (cm)	Pt	Section	Length (cm)	Pt	Section	Length (cm)
									1			1	1-2	30
1-2	2	91	121				1	35	2	1-2	25	2	2-3	
2-3									3	2-3	30	3	3-4	25
3-4	2	91	121				1	20	4	3-4	25	4	4-5	30
4-5									5	4-5		5	5-6	45
5-6	1	91	121	1	151	221	1	20	6	5-6	20	6	6-7	
6-7									7	6-7		7	7-8	
7-8									8	7-8		8	8-9	

Figure 4.28: Opening and column discontinuity inputs

Section	Direction	Disc.	Plan	Total	Quantity Check	Discontinuity Requirements	Plan Requirements
1-2	X	-2	0	-2	4,2667	0	0
2-3	Y	0	0	0	9,6333	0	0
3-4	X	-2	-1	-3	8,6000	0	0
4-5	Y	0	0	0	19,6333	0	0
5-6	X	-2	+1	-1	4,1000	0	0
6-7	Y	0	0	0	10,0000	0	0
7-8	X	0	-1	-1	13,3667	0	0

Figure 4.29: Proposed horizontal module quantity and minimum module requirements

SECTION DETAILS

Section	Module Qty	Joint Correction	Op. 1 (cm)	Op. 2 (cm)	Op. 3 (cm)	Column Disc. (cm)	CC 1st Pt. (cm)	CC 2nd Pt. (cm)	Result Dim. (cm)	Proposed Dim. (cm)	Revision %
1-2	4	-2	91	-	-	35	30	25	392	400	-2,0%
2-3	10	0	-	-	-	-	-	30	331	320	3,4%
3-4	9	-3	91	-	-	20	25	25	522	510	2,4%
4-5	20	0	-	-	-	-	30	-	631	620	1,8%
5-6	4	-1	91	151	-	20	44	20	447	450	-0,7%
6-7	10	0	-	-	-	-	-	-	300	300	0,0%
7-8	13	-1	-	-	-	-	-	-	389	400	-2,8%

CORNER COORDINATES

CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y
1	0	0	0	0
2	400	0	392	0
3	400	-320	392	-331
4	910	-320	914	-331
5	910	300	914	300
6	1360	300	1361	300
7	1360	0	1361	0
8	1760	0	1750	0

SUGGESTION Z

qty.	cm	revision
28	281	-3,1%
-	-	-

STAGGERING
15 cm

Figure 4.30: Horizontal and vertical section details, corner coordinates and amount of stagger suggested by the program

The results are the same as of previous example except for module quantities which are affected by opening discontinuities that were missing in the previous example. Appendix 1g and 1h are the plan view and elevation drawings of this façade

4.3.2 Curtain Wall Façades

In this section a curtain wall façade consisting of six corner points and five sections is solved five times each time with different section properties. In the first problem the façade is constructed using only a single component, in the second problem two different components are used together but none of them is prioritized. In the third problem two components are used and one of them is prioritized. In the fourth and fifth problems four different components are used and a component is prioritized in the latter.

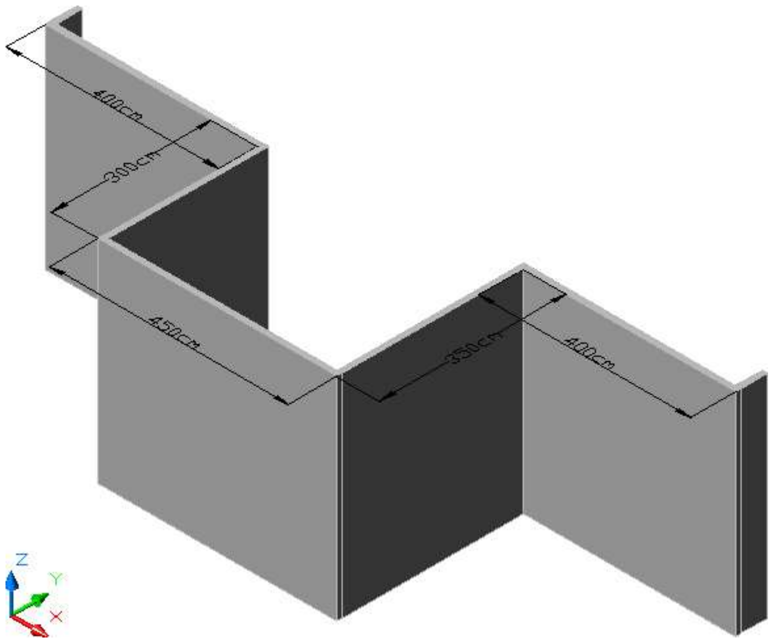


Figure 4.31: Proposed curtain wall façade to be solved by the program

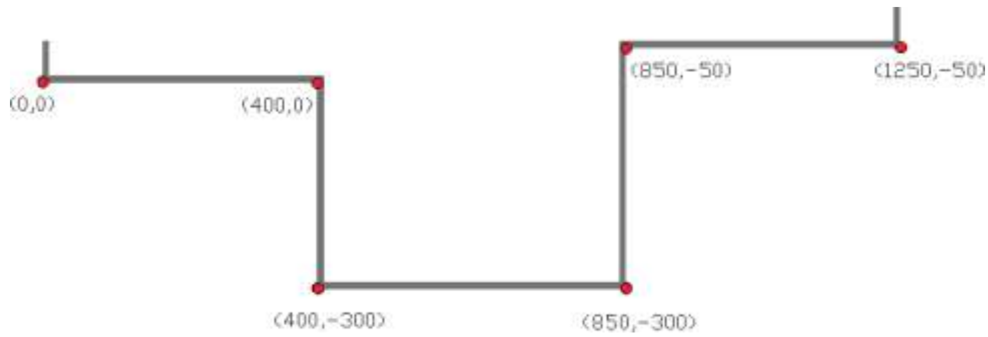


Figure 4.32: Corners coordinates of the proposed curtain wall façade

The corner coordinates of the proposed façade are entered to the program as follows;

#	X(cm)	Y(cm)
1	0	0
2	400	0
3	400	-300
4	850	-300
5	850	50
6	1250	50

Figure 4.33: Corner coordinates of the proposed curtain wall façade

According to the coordinate data of the proposed corner points section properties are determined by the program as follows;

Pt	X	Y	Δx1	Δy1	Δx2	Δy2	Corners	Section	|Δ|	Direction
1	0	0					Outward			
2	400	0	400	0	0	-300	Inward	1-2	400	X
3	400	-300	0	-300	450	0	Outward	2-3	300	Y
4	850	-300	450	0	0	350	Outward	3-4	450	X
5	850	50	0	350	400	0	Inward	4-5	350	Y
6	1250	50	400	0	-1250	-50	Outward	5-6	400	X

Figure 4.34: Section properties of the proposed curtain wall façade

4.3.2.1 Curtain Wall Façade Example Employing a Single Component

In this example the curtain wall is dimensioned using a single component. A $6cm \times 6cm$ sized corner element is placed on the corners. When using a 2cm thick panel it affects dimensioning by 2cm and 4cm on inward and outward corners respectively.

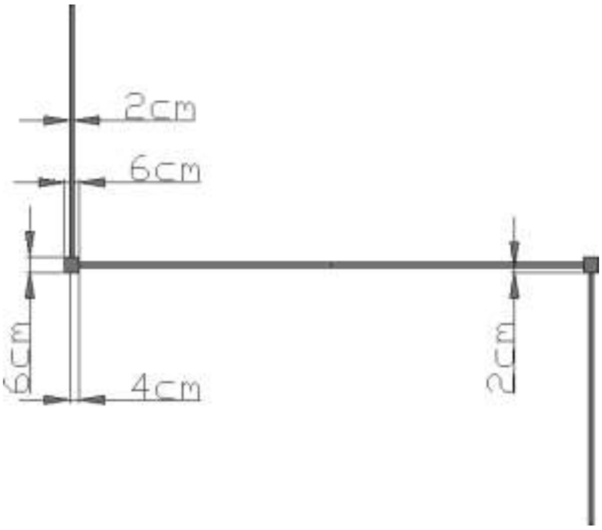
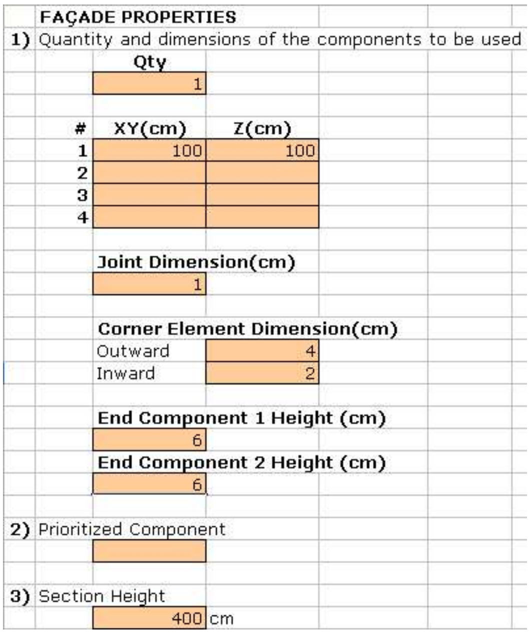


Figure 4.35: Effect of corner element on inward and outward corners



	FAÇADE PROPERTIES		
1)	Quantity and dimensions of the components to be used		
		Qty	
		1	
	#	XY(cm)	Z(cm)
	1	100	100
	2		
	3		
	4		
		Joint Dimension(cm)	
		1	
		Corner Element Dimension(cm)	
		Outward	4
		Inward	2
		End Component 1 Height (cm)	
		6	
		End Component 2 Height (cm)	
		6	
2)	Prioritized Component		
3)	Section Height		
		400	cm

Figure 4.36: Single element curtain wall inputs

When using a single component, artificial component is the component itself. The modular dimension is calculated as the sum of component dimensions and joint thickness. Also when using a single component no element can be prioritized among others and the program calculates startxy and startz values as zero.

SumXY	SumZ	Start XY	Start Z
101	101	0	0

Figure 4.37: Single element curtain wall AC and prioritized component dimensions

The proposed module quantity is calculated by using formula 3.16 and 3.17 as follows;

Section	1st End Element	2nd End Element	Joint Plan	Dimension Check
1-2	4	2	-1	3,910891089
2-3	2	4	-1	2,920792079
3-4	4	4	-1	4,386138614
4-5	4	2	-1	3,415841584
5-6	2	4	-1	3,910891089

Figure 4.38: Single element curtain wall proposed horizontal module quantity

CORNER DETAILS						
CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y	SUGGESTION Z	
1	0	0	0	0	415	3,8%
2	400	0	409	0	-	-
3	400	-300	409	-308		
4	850	-300	820	-308		
5	850	50	820	0		
6	1250	50	1229	0		

SECTION DETAILS					
Section	Module Qty	Joint Correction	Result Dim.	Proposed Dim.	Revision %
1-2	4	-1	409	400	2,3%
2-3	3	-1	308	300	2,7%
3-4	4	-1	411	450	-8,7%
4-5	3	-1	308	350	-12,0%
5-6	4	-1	409	400	2,3%

Figure 4.39: Single element curtain wall horizontal and vertical section details and corner coordinates suggested by the program

Attachments 1i and 1j are plan view and elevation drawings of the results of this example.

4.3.2.2 Curtain Wall Façade Example Employing Two Components

In this example a curtain wall façade is be dimensioned using two components. None of the components is prioritized.

FAÇADE PROPERTIES

1) Quantity and dimensions of the components to be used

Qty
2

#	XY(cm)	Z(cm)
1	100	20
2	50	20
3		
4		

Joint Dimension(cm)
1

Corner Element Dimension(cm)	
Outward	4
Inward	2

End Component 1 Height (cm)
6

End Component 2 Height (cm)
6

2) Prioritized Component

3) Section Height

400	cm

Figure 4.40: Two element curtain wall inputs

The two components have the same height and different thicknesses. The artificial component must be formed by placing them next to each other, its height is equal to components' modular height and its length is equal to the sum of the modular lengths of the components as in formula 3.14. Since no component is prioritized the program calculates startxy and startz values as zero.

SumXY	SumZ		Start XY	Start Z
152	21		0	0

Figure 4.41: Two element curtain wall AC and prioritized component dimensions

The proposed module quantity is calculated by using formulae 3.16 and 3.17 as follows;

Section	1st End Element	2nd End Element	Joint Plan	Dimension Check
1-2	4	2	-1	2,598684211
2-3	2	4	-1	1,940789474
3-4	4	4	-1	2,914473684
4-5	4	2	-1	2,269736842
5-6	2	4	-1	2,598684211

Figure 4.42: Two element curtain wall proposed horizontal module quantity

CORNER DETAILS					SUGGESTION	
CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y	Z	
1	0	0	0	0	410	2,5%
2	400	0	461	0	-	-
3	400	-300	461	-309		
4	850	-300	924	-309		
5	850	50	924	0		
6	1250	50	1385	0		

SECTION DETAILS					
Section	Module Qty	Joint Correction	Result Dim.	Proposed Dim.	Revision %
1-2	3	-1	461	400	15,3%
2-3	2	-1	309	300	3,0%
3-4	3	-1	463	450	2,9%
4-5	2	-1	309	350	-11,7%
5-6	3	-1	461	400	15,3%

Figure 4.43: Two element curtain wall horizontal and vertical section details and corner coordinates suggested by the program

Appendix 1k and 1l are plan view and elevation drawings of the results of this example.

4.3.2.3 Curtain Wall Façade Example Employing Two Components and Prioritizing One of Them

In this example a curtain wall façade will be dimensioned using two components. Component number two is prioritized.

FAÇADE PROPERTIES

1) Quantity and dimensions of the components to be used

Qty
2

#	XY(cm)	Z(cm)
1	100	20
2	50	20
3		
4		

Joint Dimension(cm): 1

Corner Element Dimension(cm)

Outward	4
Inward	2

End Component 1 Height (cm): 6

End Component 2 Height (cm): 6

2) Prioritized Component: 2

3) Section Height: 400 cm

Figure 4.44: One prioritized two element curtain wall inputs

The artificial component dimensions are the same as of previous example. Since both components have the same height, prioritizing height would have no effect on dimensioning therefore startz is calculated as zero and only the modular length of component number two is taken as startxy value.

SumXY	SumZ	Start XY	Start Z
152	21	51	0

Figure 4.45: One prioritized two element curtain wall AC and prioritized component dimensions

The proposed module quantity is calculated by subtracting prioritized component dimensions from the overall section dimensions then employing formulae 3.16 and 3.17 as follows;

Section	1st End Element	2nd End Element	Joint Plan	Dimension Check
1-2	4	2	-1	2,263157895
2-3	2	4	-1	1,605263158
3-4	4	4	-1	2,578947368
4-5	4	2	-1	1,934210526
5-6	2	4	-1	2,263157895

Figure 4.46: One prioritized two element curtain wall proposed quantity

CORNER DETAILS					SUGGESTION	
CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y	Z	
1	0	0	0	0	410	2,5%
2	400	0	360	0	-	-
3	400	-300	360	-360		
4	850	-300	874	-360		
5	850	50	874	0		
6	1250	50	1234	0		

SECTION DETAILS					
Section	Module Qty	Joint Correction	Result Dim.	Proposed Dim.	Revision %
1-2	2	-1	360	400	-10,0%
2-3	2	-1	360	300	20,0%
3-4	3	-1	514	450	14,2%
4-5	2	-1	360	350	2,9%
5-6	2	-1	360	400	-10,0%

Figure 4.47: One prioritized two element curtain wall horizontal and vertical section details and corner coordinates suggested by the program

Appendix 1m and 1n are plan view and elevation drawings of the results of this example.

4.3.2.4 Curtain Wall Façade Employing Four Components

In this example the façade will be dimensioned using four components. The input data is as follows;

FAÇADE PROPERTIES

1) Quantity and dimensions of the components to be used

	Qty	
	4	
#	**XY(cm)**	**Z(cm)**
1	100	20
2	50	20
3	100	100
4	50	100

Joint Dimension(cm): 1

Corner Element Dimension(cm)

Outward	4
Inward	2

End Component 1 Height (cm): 6

End Component 2 Height (cm): 6

2) Prioritized Component

3) Section Height: 400 cm

Figure 4.48: Four element curtain wall inputs

In total there are two modular heights and two modular lengths, the artificial component is calculated as the sum of them. Because the prioritized component section is left blank in the input page, the program calculates the modular dimension of the prioritized component as zero.

SumXY	SumZ	Start XY	Start Z
152	122	0	0

Figure 4.49: Four element curtain wall AC and prioritized component dimensions

The proposed module quantity is calculated as follows by using formula 3.16 and 3.17;

Section	1st End Element	2nd End Element	Joint Plan	Dimension Check
1-2	4	2	-1	2,598684211
2-3	2	4	-1	1,940789474
3-4	4	4	-1	2,914473684
4-5	4	2	-1	2,269736842
5-6	2	4	-1	2,598684211

Figure 4.50: Four element curtain wall proposed horizontal module quantity

CORNER DETAILS						
CORNER NO	INPUT		SUGGESTION		SUGGESTION Z	
	X	Y	X	Y		
1	0	0	0	0	377	-5,8%
2	400	0	461	0	-	-
3	400	-300	461	-309		
4	850	-300	924	-309		
5	850	50	924	0		
6	1250	50	1385	0		

SECTION DETAILS					
Section	Module Qty	Joint Correction	Result Dim.	Proposed Dim.	Revision %
1-2	3	-1	461	400	15,3%
2-3	2	-1	309	300	3,0%
3-4	3	-1	463	450	2,9%
4-5	2	-1	309	350	-11,7%
5-6	3	-1	461	400	15,3%

Figure 4.51: Four component curtain wall horizontal and vertical section details and corner coordinates suggested by the program

Because the length of the AC in this example is the same as the length of the AC in the curtain wall example with two components, the horizontal dimensioning of the resulting façades are the same. Appendix 1o and 1p are plan view and elevation drawings of the results of this example.

4.3.2.5 Curtain Wall Façade Employing Four Components and Prioritizing One of Them

The input data is the same as in the previous example except this time component number 2 is prioritized.

FAÇADE PROPERTIES		
1) Quantity and dimensions of the components to be used		
	Qty	
	4	
#	XY(cm)	Z(cm)
1	100	20
2	50	20
3	100	100
4	50	100
	Joint Dimension(cm)	
	1	
	Corner Element Dimension(cm)	
	Outward	4
	Inward	2
	End Component 1 Height (cm)	
	6	
	End Component 2 Height (cm)	
	6	
2) Prioritized Component		
	2	
3) Section Height		
	400	cm

Figure 4.52: One prioritized four element curtain wall inputs

Dimensions of the artificial module are the same as of previous example. When one component was prioritized in a two element curtain wall then the prioritized component would effect dimensioning in only one direction but when four elements are employed then the prioritized component effects dimensioning in two directions. The modular dimensions of the prioritized component are calculated as in figure 4.52.

SumXY	SumZ	Start XY	Start Z
152	122	51	21

Figure 4.53: One prioritized four element curtain wall AC and prioritized component dimensions

The proposed quantity of the sections are calculated to as follows by using formulae 3.16 and 3.17 after subtracting prioritized component dimensions from the overall section dimensions;

Section	1st End Element	2nd End Element	Joint Plan	Dimension Check
1-2	4	2	-1	2,263157895
2-3	2	4	-1	1,605263158
3-4	4	4	-1	2,578947368
4-5	4	2	-1	1,934210526
5-6	2	4	-1	2,263157895

Figure 4.54: One prioritized four element curtain wall proposed horizontal module quantity

CORNER DETAILS

CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y	SUGGESTION Z	
1	0	0	0	0	398	-0,5%
2	400	0	360	0	-	-
3	400	-300	360	-360		
4	850	-300	874	-360		
5	850	50	874	0		
6	1250	50	1234	0		

SECTION DETAILS

Section	Module Qty	Joint Correction	Result Dim.	Proposed Dim.	Revision %
1-2	2	-1	360	400	-10,0%
2-3	2	-1	360	300	20,0%
3-4	3	-1	514	450	14,2%
4-5	2	-1	360	350	2,9%
5-6	2	-1	360	400	-10,0%

Figure 4.55: One prioritized four element curtain wall horizontal and vertical section details and corner coordinates suggested by the program

Appendix 1q and 1r are plan view and elevation drawings of the results of this example.

5. CONCLUSION

Along with manufacturing industries, industrialization encouraged the production and use of high quality, precision made elements also in the building industry. Developments in construction technology were paralleled by studies aiming to define optimal dimensions for prefabricated building elements and coordinating modules that would allow a rational correlation among them.

Rather than putting forward a proposal concerning the value of the module or the value of the dimensions of building elements, in this thesis emphasis is placed on the system of rules that control dimensions of the module and elements and parts of the building formed by modules. This thesis sets forth an algorithm of designing building façades without the need to use custom made components or perform many alterations on the components, which are major consumers of time and energy for the component manufacturer, the designer, and the construction worker.

In traditional practice, in a masonry wall full, half and fractional size units are employed. A row would start with a ¾ unit, continue with full sized units and end with a ¾ unit. The staggered row would start with a ½ element and continue with full sized elements. Even without discontinuities at least three different components are involved in the process. By the set of rules and relations formulated in this study regarding components and façade dimensions formulated in the thesis, a masonry façade can be constructed using only a single component. In this process the magnitude of component dimensions is not important as long as a certain ratio among its sides and the joint thickness is satisfied. The height and length of a masonry component which obeys this ratio are suitable to become the vertical and horizontal modules respectively. Façade dimension is formed as a multiple of these modules. In case of discontinuities however the use of fractional components is inevitable whether the design is modular or not. In the proposition made a fractional component is necessary neighboring discontinuities.

Dimensioning of curtain wall façades is much simpler compared to masonry without limitations on the ratio within a component's sides and joint thickness or the involvement of a secondary component to neighbor discontinuities.

Curtain walls are a form of esthetic expression compared to masonry which is usually hidden behind other components. Applications of some design principles such using multiple components or manipulations of the alignment are important considerations in their dimensioning. Manipulation of the component alignment such as choosing a specific component to start the section with creates an irregular part in the façade. The regular parts are dimensioned according to the modular principles and then combined with the irregular parts.

The program converts dimensions of a non modular façade to the closest dimensioned modular façade by making use of the algorithm formulated in the thesis. Any masonry or curtain wall façade that fits into an orthogonal reference system triad and has up to 40 corner points can make use of this program. While dimensioning masonry façades, compliance of the components and discontinuities with the formulas is necessary. While dimensioning curtain wall façades, multiple components must fulfill some dimensional relations among each other, if instead a single component is used then all dimensions are acceptable.

The new dimensions computed by the use of principles stated in this study do not dictate major changes. For example in the masonry façade examples where the horizontal module is equal to 30cm the percentage of change between the proposed and suggested dimensions rarely exceeds three percent. The smaller the module is chosen to be the nearer the results are to the proposed dimensions.

Only a few differently dimensioned components are employed in the construction of the façades dimensioned by the program. When an order is received by the manufacturer for such a building he is required to produce greater quantities of fewer items rather than smaller quantities of a multiplicity of items. The longer runs required for such a production are for his benefit increasing productivity and reducing costs. If in the design process components are chosen among standardized components, by consultation to the manufacturer then a laborious research and development process required for introducing a new component is also eliminated.

Many available sizes of different products are brought together on the drawing board. The design problem is relating their dimensions. To this problem there may not be a single solution but there certainly is a more economical and efficient solution. Design work is simplified by enabling buildings to be dimensioned using fewer differently dimensioned components. The use of a grid with spacing equal to a multiple of the module helps to easily express positioning rules for components with respect to the grid and solve layout problems quickly and systematically. The proposition allows higher dimensional flexibility for curtain walls where masonry façade dimensioning based on the multiple of a single module may require a series of compromises and a high degree of discipline from the designer. When desired modular dimensions do not occur in the multiples of a single module then carefully selected modular components of different basic modules can be combined by their additive qualities to provide these modular dimensions. There is almost unlimited design flexibility in a system of modular coordination. The use of modules is limited only by the ingenuity and imagination of the designer.

Very few differently dimensioned components are used in the masonry and curtain wall façade designs by this program. Overall façade dimensions are modular so there is no shaping required to make these components fit into their positions. Without the cutting and fitting there is no wastage of materials. The required quantity of components is known for exact and there will be no excessive or insufficient ordering. With the high dimensional precision, smooth finishes implicit in the prefabricated components, the craftsmanship and man-hours required on the job is minimized. Same building can be constructed with maximum economy of labor and material costs and high speed on site.

The program does not consider building façades as a whole but as separate sides. When corner coordinates of the whole façade are entered into the program then coordinates of the first and last points would be the same because the façade has to close. But there is no guarantee that coordinates of the first and last corner points suggested by the program will be the same meaning the façade might not close. Corner coordinates are calculated with respect to the modular section dimensions. Modular section dimensions are chosen among three dimensions; the two closest modular dimensions to the proposed dimension and the minimum requirement in masonry façades. The criteria is being closest to the proposed dimensions and not being below the minimum requirements. They are not further analyzed to bring the façade to closing. The formulation of such a criterion would enable the dimensioning of the façade as a whole.

A masonry façade does not only consist of bricks or blocks. A modular vertical and horizontal coursing of these components does not necessarily satisfy the modularity requirements for other façade components such as insulation panels, veneer or interior facing tiles. This thesis can be further developed by formulating the necessary dimensional correlations between available façade components and within the components themselves. An even higher rationalization can be achieved by coordinating façades with other building elements such as floors and ceilings.

Designing a structure that can remain functional for decades is a complex task. Contributing to this complexity are short term needs of meeting budgets and schedules and the long term goal of system efficiency. Modular design seeks to resolve these demands by recognizing that a building can be designed so that it is economical to build, efficient to operate and serviceable for decades. Even with the application of the small scale optimizations suggested in this thesis, significant time and effort savings are accomplished for individual projects. But it is only by engaging all the levels of the building industry that a comprehensive increase in efficiency is possible and good things will be delivered to people much quicker and cheaper,

BIBLIOGRAPHY

Badii, L., http://materia.it/materia/normativeScheda?id=1440659990.

Darlington, R.P., Isenberg, M.W. and Pierce, D.A, eds., 1962. Modular Practice, John Wiley & Sons Inc., New York.

Conrad, F., Cziesielski, E., Frenzel, D, and others, 1990. Lehrbuch der Hochbau-Konstruktionen, B.G. Teubner, Stuttgart.

Garcia, P. L., 1969. Approach to Architectural Design, Proceedings of a Conference Held at Gaithersburg, Md. USA September 24-26.

Groak, S, 1992. The Idea of Building, E&FN Spon, London.

Hyde, J. R, 1969. The Missing Five Percent, Proceedings of a Conference Held at Gaithersburg, Md. USA September 24-26.

Kroll, L, 1987. An Architecture of Complexity, MIT Press, Cambridge.

Kozluca, A, 1983. Binaların Dış Özellikleri Hakkındaki Tasarlama Kararlarının Sistemleştirilmesi Konusunda Bir Deneme, Master Thesis, I.T.U Institute of Science and Technology, Istanbul.

Leon, G, 1971. The Economics and Management of System Construction, Longman Group Limited, London.

Schittich, C ed., 2001. In Detail: Building Skins, Birkhauser, Basel.

Stevens, G, 1990. The Reasoning Architect, pp 180-183, McGraw Hill Publishing Company, Singapore.

Tuna, D, 1976. Tasarımda ve Uygulamada Modül, Ege Üniversitesi Mühendislik Bilimleri Fakültesi Yayınları, İzmir.

HORIZONTAL MODULE (cm)			VERTICAL MODULE (cm)		
1	**M**	**0**	**1**	**M**	**0**
1	M+Joint	0	1	M+Joint	0
2	M+Joint	0	2	M+Joint	0
3	M+Joint	0	3	M+Joint	0
4	M+Joint	0	4	M+Joint	0
5	M+Joint	0	5	M+Joint	0
6	M+Joint	0	6	M+Joint	0
7	M+Joint	0	7	M+Joint	0
8	M+Joint	0	8	M+Joint	0
9	M+Joint	0	9	M+Joint	0
10	M+Joint	0	10	M+Joint	0
11	M+Joint	0	11	M+Joint	0
12	M+Joint	0	12	M+Joint	0
13	M+Joint	0	13	M+Joint	0
14	M+Joint	0	14	M+Joint	0
15	M+Joint	0	15	M+Joint	0
16	M+Joint	0	16	M+Joint	0
17	M+Joint	0	17	M+Joint	0
18	M+Joint	0	18	M+Joint	0
19	M+Joint	0	19	M+Joint	0
20	M+Joint	0	20	M+Joint	0
21	M+Joint	0	21	M+Joint	0
22	M+Joint	0	22	M+Joint	0
23	M+Joint	0	23	M+Joint	0
24	M+Joint	0	24	M+Joint	0
25	M+Joint	0	25	M+Joint	0
26	M+Joint	0	26	M+Joint	0
27	M+Joint	0	27	M+Joint	0
28	M+Joint	0	28	M+Joint	0
29	M+Joint	0	29	M+Joint	0
30	M+Joint	0	30	M+Joint	0
31	M+Joint	0	31	M+Joint	0
32	M+Joint	0	32	M+Joint	0
33	M+Joint	0	33	M+Joint	0
34	M+Joint	0	34	M+Joint	0
35	M+Joint	0	35	M+Joint	0
36	M+Joint	0	36	M+Joint	0
37	M+Joint	0	37	M+Joint	0
38	M+Joint	0	38	M+Joint	0
39	M+Joint	0	39	M+Joint	0
40	M+Joint	0	40	M+Joint	0
41	M+Joint	0	41	M+Joint	0
42	M+Joint	0	42	M+Joint	0
43	M+Joint	0	43	M+Joint	0
44	M+Joint	0	44	M+Joint	0
45	M+Joint	0	45	M+Joint	0
46	M+Joint	0	46	M+Joint	0
47	M+Joint	0	47	M+Joint	0
48	M+Joint	0	48	M+Joint	0
49	M+Joint	0	49	M+Joint	0
50	M+Joint	0	50	M+Joint	0
51	M+Joint	0	51	M+Joint	0
52	M+Joint	0	52	M+Joint	0

53	M+Joint	0	53	M+Joint	0
54	M+Joint	0	54	M+Joint	0
55	M+Joint	0	55	M+Joint	0
56	M+Joint	0	56	M+Joint	0
57	M+Joint	0	57	M+Joint	0
58	M+Joint	0	58	M+Joint	0
59	M+Joint	0	59	M+Joint	0
60	M+Joint	0	60	M+Joint	0
61	M+Joint	0	61	M+Joint	0
62	M+Joint	0	62	M+Joint	0
63	M+Joint	0	63	M+Joint	0
64	M+Joint	0	64	M+Joint	0
65	M+Joint	0	65	M+Joint	0
66	M+Joint	0	66	M+Joint	0
67	M+Joint	0	67	M+Joint	0
68	M+Joint	0	68	M+Joint	0
69	M+Joint	0	69	M+Joint	0
70	M+Joint	0	70	M+Joint	0
71	M+Joint	0	71	M+Joint	0
72	M+Joint	0	72	M+Joint	0
73	M+Joint	0	73	M+Joint	0
74	M+Joint	0	74	M+Joint	0
75	M+Joint	0	75	M+Joint	0
76	M+Joint	0	76	M+Joint	0
77	M+Joint	0	77	M+Joint	0
78	M+Joint	0	78	M+Joint	0
79	M+Joint	0	79	M+Joint	0
80	M+Joint	0	80	M+Joint	0
81	M+Joint	0	81	M+Joint	0
82	M+Joint	0	82	M+Joint	0
83	M+Joint	0	83	M+Joint	0
84	M+Joint	0	84	M+Joint	0
85	M+Joint	0	85	M+Joint	0
86	M+Joint	0	86	M+Joint	0
87	M+Joint	0	87	M+Joint	0
88	M+Joint	0	88	M+Joint	0
89	M+Joint	0	89	M+Joint	0
90	M+Joint	0	90	M+Joint	0
91	M+Joint	0	91	M+Joint	0
92	M+Joint	0	92	M+Joint	0
93	M+Joint	0	93	M+Joint	0
94	M+Joint	0	94	M+Joint	0
95	M+Joint	0	95	M+Joint	0
96	M+Joint	0	96	M+Joint	0
97	M+Joint	0	97	M+Joint	0
98	M+Joint	0	98	M+Joint	0
99	M+Joint	0	99	M+Joint	0
100	M+Joint	0	100	M+Joint	0

FAÇADE PROPERTIES

1) Enter corner coordinates

2) Enter the dimensions of the component to be

Length(cm)	**Height(cm)**	**Thickness(cm)**

3) Enter storey clearance
cm

4) Enter the type, location and dimensions of
You may enter three different types of oper
The height and lengths of all discontinutie
For column disconitinuities height is not r

5) Enter the length and quantity of corner col
Enter only the length of column that lies b
Corner column dimensions must be inclusive

Pt #	**X(cm)**	**Y(cm)**	**Section**
1			
2			1-2
3			2-3
4			3-4
5			4-5
6			5-6
7			6-7
8			7-8
9			8-9
10			9-10
11			10-11
12			11-12
13			12-13
14			13-14
15			14-15
16			15-16
17			16-17
18			17-18
19			18-19
20			19-20
21			20-21
22			21-22
23			22-23
24			23-24
25			24-25
26			25-26
27			26-27
28			27-28
29			28-29
30			29-30
31			30-31
32			31-32

33	32- 33
34	33- 34
35	34- 35
36	35- 36
37	36- 37
38	37- 38
39	38- 39
40	39- 40

e used

the discontunities on the façade sections.
nings and a column discontinuity for each section
es must be modular, refer to module calculator fo
required.

umns in the last section.
between corner points.
of one joint Length.

Opening Discontinuity 1		
Qty. of Discontinuity 1 in Section	Length (cm)	Height (cm)

ı.
ır modular dimensions.

Opening Discontinuity 2 Qty. of Discontinuity 2 in Section	Length (cm)	Height (cm)

Opening Discontinuity 3			Column Disc
Qty. of Discontinuity 3 in Section	Length (cm)	Height (cm)	Qty. of Column

:ontinuity Length (cm)	Pt	Section	Corner Columns Length (cm)	Pt	Section	Length (cm)
	1			1	1-2	
	2	1-2		2	2-3	
	3	2-3		3	3-4	
	4	3-4		4	4-5	
	5	4-5		5	5-6	
	6	5-6		6	6-7	
	7	6-7		7	7-8	
	8	7-8		8	8-9	
	9	8-9		9	9-10	
	10	9-10		10	10-11	
	11	10-11		11	11-12	
	12	11-12		12	12-13	
	13	12-13		13	13-14	
	14	13-14		14	14-15	
	15	14-15		15	15-16	
	16	15-16		16	16-17	
	17	16-17		17	17-18	
	18	17-18		18	18-19	
	19	18-19		19	19-20	
	20	19-20		20	20-21	
	21	20-21		21	21-22	
	22	21-22		22	22-23	
	23	22-23		23	23-24	
	24	23-24		24	24-25	
	25	24-25		25	25-26	
	26	25-26		26	26-27	
	27	26-27		27	27-28	
	28	27-28		28	28-29	
	29	28-29		29	29-30	
	30	29-30		30	30-31	
	31	30-31		31	31-32	
	32	31-32		32	32-33	

33	32-33	33	33-34
34	33-34	34	34-35
35	34-35	35	35-36
36	35-36	36	36-37
37	36-37	37	37-38
38	37-38	38	38-39
39	38-39	39	39-40
40	39-40	40	

Pt #	X	Y	Opening 1	Opening 2	Opening 3	Midway Column
1	0	0				
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0

Pt #	Section	Disc. 1 Qty	Disc. 1 Height	Disc. 2 Qty	Disc. 2 Height	Disc. 3 Qty
1						
2	1-2	0	0	0	0	0
3	2-3	0	0	0	0	0
4	3-4	0	0	0	0	0
5	4-5	0	0	0	0	0
6	5-6	0	0	0	0	0
7	6-7	0	0	0	0	0
8	7-8	0	0	0	0	0
9	8-9	0	0	0	0	0
10	9-10	0	0	0	0	0
11	10-11	0	0	0	0	0
12	11-12	0	0	0	0	0

13	12-13	0	0	0	0	0
14	13-14	0	0	0	0	0
15	14-15	0	0	0	0	0
16	15-16	0	0	0	0	0
17	16-17	0	0	0	0	0
18	17-18	0	0	0	0	0
19	18-19	0	0	0	0	0
20	19-20	0	0	0	0	0
21	20-21	0	0	0	0	0
22	21-22	0	0	0	0	0
23	22-23	0	0	0	0	0
24	23-24	0	0	0	0	0
25	24-25	0	0	0	0	0
26	25-26	0	0	0	0	0
27	26-27	0	0	0	0	0
28	27-28	0	0	0	0	0
29	28-29	0	0	0	0	0
30	29-30	0	0	0	0	0
31	30-31	0	0	0	0	0
32	31-32	0	0	0	0	0
33	32-33	0	0	0	0	0
34	33-34	0	0	0	0	0
35	34-35	0	0	0	0	0
36	35-36	0	0	0	0	0
37	36-37	0	0	0	0	0
38	37-38	0	0	0	0	0
39	38-39	0	0	0	0	0
40	39-40	0	0	0	0	0

C.C. 1st Pt.	C.C. Width	C.C. 2nd Pt.	C.C. Width	Δx1	Δy1	Δx2
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Disc. 3 Height	Disc. 1 Version	Module Qty 1	Module Qty 2	Disc.2 Version	Module Qty 1	Module Qty 2
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######

0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######
0	######	######	#######	#######	#######	#######

Δy2	|Δ|	Corners Outward Outward	Corners Inward	Corner Outward	Section #
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	1-2
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	2-3
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	3-4
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	4-5
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	5-6
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	6-7
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	7-8
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	8-9
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	9-10
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	10-11
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	11-12
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	12-13
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	13-14
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	14-15
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	15-16
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	16-17
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	17-18
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	18-19
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	19-20
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	20-21
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	21-22
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	22-23
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	23-24
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	24-25
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	25-26
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	26-27
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	27-28
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	28-29
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	29-30
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	30-31
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	31-32
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	32-33
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	33-34
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	34-35
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	35-36
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	36-37
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	37-38
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	38-39
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	39-40

Disc.3 Version	Module Qty 1	Module Qty 2	D1 Height 1	D2 Height 1	D3 Height 1
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!

#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!
#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!	#SAYI / 0!

Direction	Disc.	Plan	Total	Quantity Check
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ
NONE	0	YANLIŞ	0	YANLIŞ

D1 Height 2	D2 Height 2	D3 Height 2	Height 1	Height 2
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!

#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
#SAYI/0!	#SAYI/0!	#######	#SAYI/0!	#SAYI/0!
			#SAYI/0!	#SAYI/0!

Discontinuity Requirements	Plan Requirements	Suggestion1 Quantity	Suggestion 2 Quantity
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Suggestion1 Dimensions	Suggestion 2 Dimensions	$\|\Delta\|$	Direction	Δx	Δy
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0
0	0	YANLIŞ	NONE	0	0

Suggestion Qty	Suggestion Dimensions X	Y	Suggestion Coordinates X	Y	Inp Coordi X
	0	0	0	0	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0

›out
nat es
Y

0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0

CORNER COORDINATES

CORNER	INPUT		SUGGESTION	
NO	X	Y	X	Y
1	0	0	0	0
2	0	0	-	-
3	0	0	-	-
4	0	0	-	-
5	0	0	-	-
6	0	0	-	-
7	0	0	-	-
8	0	0	-	-
9	0	0	-	-
10	0	0	-	-
11	0	0	-	-
12	0	0	-	-
13	0	0	-	-
14	0	0	-	-
15	0	0	-	-
16	0	0	-	-
17	0	0	-	-
18	0	0	-	-
19	0	0	-	-
20	0	0	-	-
21	0	0	-	-
22	0	0	-	-
23	0	0	-	-
24	0	0	-	-
25	0	0	-	-
26	0	0	-	-
27	0	0	-	-
28	0	0	-	-
29	0	0	-	-
30	0	0	-	-
31	0	0	-	-
32	0	0	-	-
33	0	0	-	-
34	0	0	-	-
35	0	0	-	-
36	0	0	-	-
37	0	0	-	-
38	0	0	-	-
39	0	0	-	-
40	0	0	-	-

SECTION DETAILS

Section	Module Qty	Joint Correction	Op. 1	Op. 2	Op. 3	Column Disc.	CC 1st Pt.	CC 2nd Pt.	Result Dim.
1 - 2	0	0	-	-	-	-	-	-	-
2 - 3	0	0	-	-	-	-	-	-	-
3 - 4	0	0	-	-	-	-	-	-	-
4 - 5	0	0	-	-	-	-	-	-	-
5 - 6	0	0	-	-	-	-	-	-	-
6 - 7	0	0	-	-	-	-	-	-	-
7 - 8	0	0	-	-	-	-	-	-	-
8 - 9	0	0	-	-	-	-	-	-	-
9 - 10	0	0	-	-	-	-	-	-	-
10 - 11	0	0	-	-	-	-	-	-	-
11 - 12	0	0	-	-	-	-	-	-	-
12 - 13	0	0	-	-	-	-	-	-	-
13 - 14	0	0	-	-	-	-	-	-	-
14 - 15	0	0	-	-	-	-	-	-	-
15 - 16	0	0	-	-	-	-	-	-	-
16 - 17	0	0	-	-	-	-	-	-	-
17 - 18	0	0	-	-	-	-	-	-	-
18 - 19	0	0	-	-	-	-	-	-	-
19 - 20	0	0	-	-	-	-	-	-	-
20 - 21	0	0	-	-	-	-	-	-	-
21 - 22	0	0	-	-	-	-	-	-	-
22 - 23	0	0	-	-	-	-	-	-	-
23 - 24	0	0	-	-	-	-	-	-	-
24 - 25	0	0	-	-	-	-	-	-	-
25 - 26	0	0	-	-	-	-	-	-	-
26 - 27	0	0	-	-	-	-	-	-	-
27 - 28	0	0	-	-	-	-	-	-	-
28 - 29	0	0	-	-	-	-	-	-	-
29 - 30	0	0	-	-	-	-	-	-	-
30 - 31	0	0	-	-	-	-	-	-	-
31 - 32	0	0	-	-	-	-	-	-	-
32 - 33	0	0	-	-	-	-	-	-	-
33 - 34	0	0	-	-	-	-	-	-	-
34 - 35	0	0	-	-	-	-	-	-	-
35 - 36	0	0	-	-	-	-	-	-	-
36 - 37	0	0	-	-	-	-	-	-	-
37 - 38	0	0	-	-	-	-	-	-	-
38 - 39	0	0	-	-	-	-	-	-	-
39 - 40	0	0	-	-	-	-	-	-	-

Proposed Revision	
Dim.	%
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-
-	-

#######	#######	#######
#######	#######	**#######**

0 cm

FAÇADE PROPERTIES

1) Quantity and dimensions of the components to be used

#	Qty	XY(cm)	Z(cm)
1			
2			
3			
4			

Joint Dimension(cm)

Corner Element Dimension(cm)

Outward

Inward

End Component 1 Height (cm)

End Component 2 Height (cm)

2) Prioritized Component

3) Section Height

cm

4) Corner Coordinates

#	X(cm)	Y(cm)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		

1
2
4

	X	**Y**
1	YANLIŞ	YANLIŞ

	X	**Y**		**SumXY**	**SumZ**
2	YANLIŞ	YANLIŞ		YANLIŞ	YANLIŞ
	YANLIŞ	YANLIŞ			

	X	**Y**			
4	YANLIŞ	YANLIŞ		YANLIŞ	YANLIŞ
	YANLIŞ	YANLIŞ		YANLIŞ	YANLIŞ
	YANLIŞ	YANLIŞ			
	YANLIŞ	YANLIŞ		YANLIŞ	YANLIŞ

	SumXY	**SumZ**		**Start XY**	**Start Z**
	YANLIŞ	YANLIŞ		0	0

Pt	X	Y	Δx1	Δy1	Δx2	Δy2
1	0	0				
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
30	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0

Non Modular Comp Qty			Height	
			Height 1	Height 2
#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!	#SAYI/0!

Start XY	Start Z
0	0

SumXY	SumZ
YANLIŞ	YANLIŞ

Start XY	Start Z
0	0

|∆|	Corner Outward Outward	Corner Inward	All Corners Outward	Section	Direction
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	1-2	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	2-3	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	3-4	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	4-5	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	5-6	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	6-7	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	7-8	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	8-9	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	9-10	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	10-11	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	11-12	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	12-13	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	13-14	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	14-15	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	15-16	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	16-17	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	17-18	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	18-19	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	19-20	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	20-21	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	21-22	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	22-23	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	23-30	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	30-25	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	25-26	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	26-27	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	27-28	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	28-29	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	29-30	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	30-31	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	31-32	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	32-33	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	33-34	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	34-35	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	35-36	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	36-37	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	37-38	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	38-39	NONE
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	39-40	NONE

1st End Element	2nd End Element	Joint Plan	Dimension Check	Suggestion1 Quantity
0	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0

Suggestion 2 Quantity	Suggestion1 Dimensions	Suggestion 2 Dimensions	Δx	Δy
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0
0	YANLIŞ	YANLIŞ	0	0

Suggestion Quantity	Suggestion Dimensions X	Y	Suggestion Coordinates X	Y	Inp Coordi X
			0	0	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0
0	YANLIŞ	YANLIŞ	YANLIŞ	YANLIŞ	0

out
nat es

Y
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0

CORNER DETAILS

CORNER NO	INPUT X	INPUT Y	SUGGESTION X	SUGGESTION Y
1	0	0	0	0
2	0	0	-	-
3	0	0	-	-
4	0	0	-	-
5	0	0	-	-
6	0	0	-	-
7	0	0	-	-
8	0	0	-	-
9	0	0	-	-
10	0	0	-	-
11	0	0	-	-
12	0	0	-	-
13	0	0	-	-
14	0	0	-	-
15	0	0	-	-
16	0	0	-	-
17	0	0	-	-
18	0	0	-	-
19	0	0	-	-
20	0	0	-	-
21	0	0	-	-
22	0	0	-	-
23	0	0	-	-
24	0	0	-	-
25	0	0	-	-
26	0	0	-	-
27	0	0	-	-
28	0	0	-	-
29	0	0	-	-
30	0	0	-	-
31	0	0	-	-
32	0	0	-	-
33	0	0	-	-
34	0	0	-	-
35	0	0	-	-
36	0	0	-	-
37	0	0	-	-
38	0	0	-	-
39	0	0	-	-
40	0	0	-	-

SECTION DETAILS

Section	Module Qty	Joint Correction	Result Dim.	Proposed Dim.	Revision %
1-2	0	0	-	-	-
2-3	0	0	-	-	-
3-4	0	0	-	-	-
4-5	0	0	-	-	-
5-6	0	0	-	-	-
6-7	0	0	-	-	-
7-8	0	0	-	-	-
8-9	0	0	-	-	-
9-10	0	0	-	-	-
10-11	0	0	-	-	-
11-12	0	0	-	-	-
12-13	0	0	-	-	-
13-14	0	0	-	-	-
14-15	0	0	-	-	-
15-16	0	0	-	-	-
16-17	0	0	-	-	-
17-18	0	0	-	-	-
18-19	0	0	-	-	-
19-20	0	0	-	-	-
20-21	0	0	-	-	-
21-22	0	0	-	-	-
22-23	0	0	-	-	-
23-24	0	0	-	-	-
24-25	0	0	-	-	-
25-26	0	0	-	-	-
26-27	0	0	-	-	-
27-28	0	0	-	-	-
28-29	0	0	-	-	-
29-30	0	0	-	-	-
30-31	0	0	-	-	-
31-32	0	0	-	-	-
32-33	0	0	-	-	-
33-34	0	0	-	-	-
34-35	0	0	-	-	-
35-36	0	0	-	-	-
36-37	0	0	-	-	-
37-38	0	0	-	-	-
38-39	0	0	-	-	-
39-40	0	0	-	-	-

#SAYI / 0!   #SAYI / 0!

#SAYI / 0!   #SAYI / 0!

CURRICULUM VITAE

Born in 1980 in Istanbul, she attended to Işık Lisesi primary school and Koç Özel Lisesi high school. In 1997 she entered to the Istanbul Technical University civil engineering program. Since 2001, the year of her graduation as a civil engineer, she is enrolled in the building technology masters program in the architectural faculty of the same university.